REPORT OF THE CHEMIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY,
Washington, D. C., July 1, 1921.

SIR: I submit herewith the report of the work of the Bureau of Chemistry for the fiscal year ended June 30, 1921.

Respectfully,

C. L. ALSBERG,
Chief of Bureau.

Hon. HENRY C. WALLACE,
Secretary of Agriculture.

When, about January 1, 1913, the Bureau of Chemistry passed to new leadership two tasks in general confronted the new chief. One was to improve the character and volume of the bureau's scientific research; the other was to make the enforcement of the food and drugs act more effective through the establishment of satisfactory cooperative relations with food and drug law enforcing officials in the States and municipalities, as well as through the development of greater uniformity in the exercise of food and drug control throughout the country.

That the scientific research work of the bureau had lagged grew out of the fact that agricultural chemistry as a distinct and independent science had lost ground the world over, and that Congress had placed upon the Bureau of Chemistry the responsibility of enforcing the food and drugs act.

When the Division of Chemistry, out of which the Bureau of Chemistry grew, was established in the days when the Department of Agriculture was still a commission, agricultural chemistry was recognized as a definite, distinct science. In the course of time the field covered by it grew so wide, so diverse, that it became split into many special subjects. The result was that the various other bureaus of the department gradually established their own chemical laboratories. For example, the Bureau of Soils deals with the whole of soil chemistry and with the chemistry of the fertilizer industry, the Bureau of Animal Industry with the chemistry of milk production and animal nutrition, the Forest Service with the chemistry of wood and of the industries that use wood as their raw materials. Even the Bureau of Plant Industry, while it has established no extensive purely chemical laboratories, employs some chemists in its various divisions.

Such was the state of affairs in 1913, and such, to a considerable degree, it still is. Much of the field of research occupied by the Bureau of Chemistry until 1900 was in this manner lost to it. The question

that had then to be faced in 1913 was into what channels should the scientific research of the Bureau of Chemistry be directed, that it might be of the greatest service to the country and to the Department of Agriculture.

Now the object of agriculture is to feed and clothe the Nation in the best way possible, and it is for the promotion of these ends that the Department of Agriculture exists. To accomplish these ends the promotion of production is not enough. The improvement of distribution and that of utilization are equally important. It is obvious that better or more economical utilization is equivalent to an increase of production. Since the improvement of the methods of utilizing agricultural products is of vital importance not merely to the farmer but to the whole country, it was decided in formulating the research policies of the Bureau of Chemistry to study the industries that utilize agricultural products, as well as to endeavor to create new or enlarge existing outlets for such products. This involved the development of a portion of the Bureau of Chemistry as a utilization service. Such a bureau, dealing with many of the industries that use agricultural products as their raw material, might be made extremely useful not merely to the agricultural interests but to the country as a whole. Since its work must articulate intimately with the production of agricultural raw materials, it can not be effective if placed elsewhere than in the Department of Agriculture.

It may perhaps be worth while to enlarge upon the value of such utilization work. The establishment of an industrial outlet for an agricultural product mainly used for food purposes may act as a stabilizer upon production and prices, since the consumption as food of such a product can not be increased largely in a year of great crop yields nor largely diminished in a year of scanty harvests. Factories, however, can operate below capacity when their raw material is scarce and high priced or work overtime when it is abundant and cheap, thus acting as a flywheel on the machinery of production and consumption. In this manner the manufacture of alcohol, starch, glucose, and dextrin has served to help in preventing gluts of potatoes in certain European countries. Had there been for corn an outlet of this general character, capable of utilizing an appreciable part of the crop, it might well have been of inestimable value to the corn-belt farmer during the past year. In the same way the development of a new outlet for a crop may mean much to the United States. Thus the area of land that can be kept under cultivation in much of the semiarid portion of the country is dependent upon the price of the grain sorghums. If it were possible to use industrially a considerable portion of the crop, for example, in the manufacture of starch, alcohol, glucose, oil, and by-product feeds, the result would be, inevitably, to bring land that can not now be farmed under the plow.

Since 1913 much work of this type has been undertaken in the Bureau of Chemistry. That more has not been accomplished is due to the Great War which kept adequate funds from being made available and caused the loss of a very large proportion of the bureau's ablest scientists. An account of some of the more notable results that have been achieved in the face of these handicaps is to be found in the following pages.

It is often a difficult problem to introduce into practical use scientific discoveries, especially when, as in the Government service,

their employment in the industries and the arts brings to the discoverer no material reward. Discoveries of great practical value not infrequently remain unused. To meet this situation, so far as the work of the scientists of the Bureau of Chemistry is concerned, an office of development work was created. As the introduction into practical use of scientific discoveries is, in the majority of cases, a matter of engineering rather than of pure science, engineers form the staff of this unit. The establishment of this office has amply justified itself and its services have been requisitioned by other bureaus of the Department of Agriculture. It is not proposed that it shall ever develop and introduce into practice inventions made outside the Government service.

Agriculture is a biological science. Even the soil teems with life. Therefore it has been the aim to develop the Bureau of Chemistry not merely as an agricultural products utilization service but also as a bureau of biochemistry. Biochemical research has been emphasized especially since 1913. To this end much of the work of the various laboratories was given a biochemical direction and in addition a protein investigation laboratory, phytochemical laboratory, microbiological laboratory, and pharmacognosy laboratory were established.

In order that the food and drugs act may be enforced effectively much original research is necessary. Few of the State or municipal officials have the opportunity, the staff, or the facilities for carrying out such researches, and they look to the Bureau of Chemistry for much of the information they require. Such regulatory investigations may in general be divided into four categories: The devising of analytical methods for the detection of sophistication; the determination of the normal range of composition of foods and drugs in order that deviations from the normal due to sophistication may be recognized; investigations to determine whether or not certain substances added to or accidentally contaminating foods are injurious to health; investigations for the improvement, control, or standardization of methods of food and drug manufacture so that manufacturers may learn to avoid inefficient and insanitary methods, very frequent causes of violation of the law. The last of these four types of investigations, since it aims to prevent and anticipate violations of the law, is essentially similar to and indeed might be classed with the utilization investigations previously discussed.

Many of these investigations demand the employment of the methods of organic chemistry, that is, of the chemistry of carbon compounds. Compounds of carbons constitute the great mass of the substances found in living things. In consequence the Bureau of Chemistry has gradually developed a large staff of organic chemists until it has come to be the chief scientific service of the Government in organic chemistry. This has resulted in the establishment of numerous contacts with that branch of the chemical industry which deals with organic substances. Such contacts were inevitable, since foods, medicines, and dyestuffs are, or consist largely of, organic substances. Since the bureau administers the food and drugs act, it has long borne as close relations to the pharmaceutical as to the food industry. With the dye industry it also long has had intimate relations, both because of its investigations upon the use of aniline dyes to color foods and because of its system of certifying to the

industry certain dyes as fit for use in food. It was therefore logical for Congress in 1916 to make an appropriation for the conduct of investigations to assist the budding American dye industry, for by that time the Bureau of Chemistry had achieved very definite recognition by chemists for its researches in organic chemistry.

Despite the many adverse conditions created by the war and discussed in the report of the chemist from year to year, the net result of the policies just outlined has been such a notable improvement in the quality and the volume of the bureau's scientific work that, during the fiscal year 1921, 140 scientific contributions were made to various technical journals. In addition, 7 department bulletins, 3 farmers' bulletins, and 3 department circulars were published and 1 department bulletin was issued jointly with another bureau. At the beginning of the fiscal year 15 applications for public service patents were pending. Eight additional applications were filed during the year; 6 were granted, 6 denied, and 11 are pending.

The responsibility for the enforcement of the food and drugs act placed upon the bureau by Congress necessarily retarded temporarily the bureau's research work because the organization of the administration of the law required, for a time at least, the services of the best minds in the bureau. It drew many of the ablest scientists into executive work and caused a sudden mushroomlike growth of the staff. Such growth always brings complications in its train. In 1913 the research functions and the regulatory functions were intimately mixed, and one was interfering with the other. Experience has shown that the same individual can not at the same time do scientific research and regulatory work and do them both well. The demands of regulatory work are immediate, those of scientific research remote. Usually research is sacrificed. Moreover, rarely is one person capable of performing both types of work equally well. Apparently one demands a different kind of mind than the other. The situation was cured, simply, effectively, and permanently, by dividing the staff into two fairly distinct services, a research and a regulatory branch. Thus only in exceptional cases has the same individual both research and regulatory duties to perform.

Such an arrangement is far preferable to the segregation of the two kinds of work in distinct bureaus. Regulatory work disconnected from research becomes wooden and unconstructive. Therefore, a purely regulatory bureau will in time develop its own research service with resulting duplications, conflicts, and vexations. Moreover, the regulatory work uncovers important problems which can be turned over to the research service for solution if both services are closely associated. Thus each service stimulates and vitalizes the other. Finally, there is the very practical consideration that men in the research service who fail to demonstrate originality may be transferred to the regulatory service where they frequently develop into excellent analysts or first-rate executives, while those in the regulatory service who show scientific originality may be recruited into the research service. Under conditions as they exist in the bureau to-day the value of both kinds of work is recognized and, while they are separated as far as practicable, the closest cooperation between the two services exists.

The segregation of the research from the regulatory work required a rearrangement of the bureau's organization. Such a reorganization was necessary not merely to separate the research from the regulatory work, but also to make the regulatory work more effective by decentralizing it so far as practicable. In 1913 the field laboratories, scattered from Hawaii to Boston and from Minneapolis to Porto Rico, reported directly to the chief of the bureau in Washington. Each inspector or group of inspectors reported directly to the chief inspector in Washington. As many inspectors were stationed in cities in which laboratories were maintained, the tendency was for them to operate independently of the chiefs of the laboratories, a source of confusion to the business world and of some friction within the service. Coordination of the work of inspection with that of the laboratories was difficult to maintain since in most localities there were two officials coordinate in authority. Moreover, neither inspectors nor chemists had been given much responsibility or much authority to take the initiative. Nearly all matters of any moment had to be passed upon in Washington. This not only deprived the field force of the stimulus that comes from the reposing of responsibility but it also overburdened the staff in Washington with such a volume of detail as to make it difficult to plan and direct the work of the force in the field. In consequence the law-enforcement work of the bureau was shaped to a not inconsiderable degree by the character of the samples collected, more or less fortuitously, by the inspectors. As a result many regulatory problems were taken up prematurely before they had been studied sufficiently to formulate a final policy or to adequately present the situation to the courts.

Such an organization of the regulatory service of the bureau as existed in 1913 was natural in the early days of the enforcement of the law when it was necessary to gather together and train a personnel in a few months. At that time few trained food or drug analysts and almost no experienced inspectors were available in the entire country. They had to be created. Obviously to inexperienced men no large measure of authority could be granted. By 1913, however, the bureau had acquired a number of experienced analysts and inspectors and many precedents had been established, either by the courts or through administrative action. It was, therefore, possible to reorganize the regulatory service so as to place a larger measure of responsibility upon the field force and at the same time to divorce the scientific from the regulatory service. This was accomplished by relegating to the field as far as possible all work that was of a regulatory character. The force in Washington then became the planning and supervising department of the bureau, its general staff, while the field force became the line or the executing department. Most of the research was concentrated in Washington, which did not preclude the establishment of special nonregulatory research laboratories in the field, such as the citrus by-products laboratory at Los Angeles, when the special character of the work demanded it.

At the same time the country was divided into three law-enforcement districts with headquarters at New York, Chicago, and San Francisco, respectively. A competent executive, responsible directly to the chief of the bureau, was placed in charge of each district and to him were made subordinate all the chemists and inspectors of the district. The districts were further subdivided into stations, each in

charge of one official responsible to the chief of the district. To the chiefs of districts a large measure of authority and initiative was granted gradually and they in turn delegated to their subordinates such authority as in the individual cases seemed to them wise. However, new matters for which no precedent or policy had been established were required to be referred to the chief or assistant chief of the bureau for decision, and the final decision as to whether or not a given case should be recommended for prosecution was reserved for the chief and assistant chief of the bureau. A system of recording the volume and character of the work of the different districts and stations was introduced and the data thus secured made accessible to the entire staff. Thus not merely was cooperation between the districts stimulated but also a healthy spirit of emulation was created between them and between the stations within a given district. This has been invaluable in promoting a sound esprit de corps and efficient work.

A system of budgeting funds that makes it almost impossible for the bureau ever to be under the necessity of asking for a deficiency appropriation was also introduced. Before the beginning of each fiscal year a definite credit is established on the bureau's books in favor of each district or other major unit of its organization. The new system of accounting makes it possible for each responsible head of such a unit to know exactly at all times the expenditures of his unit and the balance remaining to the credit of the unit. It is thus impossible for him to exceed his allotment without specific authorization from the chief of the bureau. Each unit is given the widest freedom in the matter of expenditures within the limits permitted by the fiscal regulations of the department. The wisdom of its expenditures is judged by the results it achieves.

The reorganization of the bureau in this general manner has not merely created satisfactory working conditions for the research men in Washington and made it possible for the Washington staff to take a large share in directing the field operations, but it has also increased the effectiveness of the enforcement of the law. Each year since the completion of the reorganization the number of cases sent to the courts has increased until it has become nearly double that of former years, and this with no increase in appropriations. During the fiscal year 1920–21 the increase over the preceding year was about 60 cases.

It is, of course, recognized that the number of cases sent to the courts is only a partial index of the effectiveness of the enforcement of the food and drugs act. A truer index would be the proportion of the total food and drug supply shipped in interstate commerce that is adulterated or misbranded. It is quite impossible even to estimate this. It can, however, be stated positively that only a very small proportion of the food supply subject to the law's jurisdiction is either adulterated or misbranded. The grosser forms of adulteration and misbranding commonly found before the enactment of the law are relatively scarce to-day. Present-day violations are oftenest of a more subtle character, requiring greater skill for their detection and eradication. The food and drugs act is technically and of necessity a penal statute, but in fact and in intent it is corrective legislation, and a measure of the corrective influence of the act is the true measure of accomplishment. Such corrective influence may be exercised as

much, perhaps more, by constructive educational work with food producers as by prosecutions under the act. That this is the case has long been recognized in shaping the bureau's regulatory policies. The cooperation of the food and drug industries has been sought constantly.

It has been the aim to administer the law in such a manner as not merely to protect the consumer but also to improve conditions in the industry. A vast amount of educational work has been done among producers. Many investigations have been carried on to demonstrate to them methods of better sanitation, of eliminating waste, of utilizing by-products, and of more efficient operation. Unfortunately, although the net result of this work has been large, it is of a character that can not be expressed in figures. It is, however, fair to say that to-day there is hardly a branch of the food industry that would care to return to the days of untrammeled operations which existed before the enactment of the law.

The bureau has been the country's most important training school for food and drug technologists. Many of its scientists have entered the employ of food or drug manufacturers where they have been instrumental in establishing constructive cooperation with the bureau. In many instances manufacturers have sent their technologists to the laboratories of the bureau to acquire special experience not readily obtainable elsewhere. Finally, the bureau in various ways has succeeded in making manufacturers realize that they must undertake research if their enterprises are to continue to progress. It has succeeded in making groups of manufacturers realize that it is good business for an industry to police itself effectively, thus reducing to a minimum the necessity for Government interference.

In 1913 both officials and manufacturers complained greatly of the lack of uniformity in the exercise of food control by the Federal and State Governments. Lack of uniformity increases the costs of doing business, and the increased cost is usually passed on to the consumer. It arises not merely from differences in the various laws but also from differences in the interpretation of the laws by the officials and in the application by them of different standards to the same product in different jurisdictions. To meet this situation in part, the cooperation of the Association of American Dairy, Food, and Drug Officials and of the Association of Official Agricultural Chemists was sought. A joint committee on definitions and standards has proposed for the guidance of officials definitions and standards covering a wide range of products which have been adopted almost universally. Thus one cause of lack of uniformity has been eliminated to a large extent.

Lack of uniform action on the part of officials and legislators is due not infrequently to lack of information. There was need in 1913 for some sort of clearing house for the exchange of regulatory information, not merely that in the files of the Bureau of Chemistry, but also that in the files of the various State and municipal departments and printed in journals, bulletins, and reports the world over. There was need for the elimination of a vast amount of duplications and wasted effort due to the fact that officials were not in touch with their colleagues in other localities. Therefore the office of State cooperation was established in the Bureau of Chemistry and the food commissioner of the State of Texas called to take charge. This office has

been very successful in drawing officials together, in disseminating information, in securing uniformity, and in establishing effective cooperation among the officials of the country. At the same time the bureau has welcomed such officials into its laboratories, which in many instances have served as a training school for them.

It may, therefore, be asserted in all fairness that since 1913 there has been a steady improvement in the bureau's research work, in its administration of the law, and in its general usefulness to the country as a whole. Such improvements as have been brought about have been accomplished in the face of the very adverse conditions created by the war. In times of war and reconstruction adequate funds are not available and it is almost impossible to recruit highly trained men.

FOOD AND DRUG INSPECTION STATIONS.

The chemists of the field force are stationed in 16 different cities. Most of the inspectors are stationed in the same places, with a few in other cities as well. The work of the field force is confined almost exclusively to the enforcement of the food and drugs act according to the general plans formulated by the staff in Washington. The story of what it has done since 1913, which is the story of the enforcement of the law during that period, may be found in the reports of the chemist and in the records of the courts as printed in the notices of judgment, of which 7,318 have appeared since January, 1913. During the year 1920–21, 1,677 recommendations for seizure and 608 recommendations for criminal prosecution were made through the office of the Solicitor to the Department of Justice. Table 1 gives a list of the classes of products on which action was recommended, as well as the distribution of the recommendations among the various types of products.

TABLE 1.—*Recommendations of actions on alleged violations of the food and drugs act transmitted to the Solicitor.*

Article.	Criminal actions.	Seizures.	Article.	Criminal actions.	Seizures.
Alimentary pastes	12	10	Ice cream	2	.....
Apple products	.....	4	Ice cream cones	.....	1
Apples, evaporated	18	.....	Jams and marmalade	.....	2
Beans, lima, fava, etc	.....	6	Nuts, walnuts, peanuts (shelled and butter)	3	9
Beverages and beverage ingredients	12	69	Oils, birch, wintergreen, etc	7	5
Bread and cake	6	.....	Oils, salad, olive, table, etc	26	44
Candy, marshmallow crême	3	2	Oleomargarine	2	.....
Chocolate coating and liquor	.....	9	Olives, ripe or canned	1	1
Cocoa	13	.....	Pies, pie filling	8	14
Coconut	.....	2	Potatoes	5	.....
Coffee, green	.....	2	Prunes	1	3
Colors, food	8	71	Rice	.....	2
Dairy products (butter, condensed and fresh milk)	15	7	Saccharin	.....	2
Drugs, crude	8	1	Sauerkraut	2	3
Drugs, various remedies	51	815	Shellfish	53	2
Drugs, stock remedies	7	121	Sirups, table, maple, molasses	6	9
Drugs, venereal disease remedies	5	69	Soups, concentrated and vegetable	.....	6
Eggs, frozen, desiccated pulp, and liquid whole	1	5	Spices, relishes, condiments, sage	6	47
Eggs, shell	60	5	Sweeteners	.....	35
Egg substitute	.....	10	Tomato products	21	79
Feeds, stock	134	18	Tomatoes, bulk (net weight)	5	.....
Fish, canned	18	45	Turpentine	3	.....
Flavoring materials	18	11	Vegetables, bulk (net weight)	7	.....
Flour	1	5	Vegetables, canned	.....	4
Fruits, bulk (net weight)	37	.....	Vinegar	5	85
Fruits, canned	.....	16	Water, mineral	18	15
Fruits, dried	.....	5			
Gelatin	.....	1	Total	608	1,677

Examination of Table 1 shows that prosecution was recommended most frequently upon shipments of patent medicines, including stock remedies, of stock feeds, beverages, eggs, food colors, fish and shellfish, salad oils, vinegars, artificial sweeteners, and tomato products.

The activities of the year on patent medicines were a continuation of those reported last year. Especial attention was given to preparations labeled as treatments for lost manhood, suppressed menstruation, and hog cholera. In its work on the last-named type of remedies the bureau has received the continued cooperation of the Bureau of Animal Industry.

As in the past, the cases developed against stock feeds have involved principally cottonseed products deficient in protein or otherwise failing to conform to the claims made upon the labels.

Imitation fruit beverages sold under labels implying the presence of substantial quantities of fruit juice are still being encountered, but as a result of the bureau's operations an increasing number of manufacturers have revised their labels to accord with the true composition of their products, or have actually incorporated fruit juice as an essential ingredient of the article. It has been necessary to continue the seizure of vinegar made from dried-apple products bearing labels which represent it as manufactured from the pressed juice of fresh apples. This type of substitution has exerted a seriously demoralizing effect upon the trade in genuine apple-cider vinegar.

One of the most persistent and petty types of violation which the bureau has been called upon to prevent is the short weighting of tins of vegetable oil. There is a widespread practice habitual among the smaller packers of this commodity to put out packages showing a comparatively small but constant shortage from the declared quantity of the contents. In the long run this shortage results in a substantial profit to the packer, which the consumer pays. These packers also persist in adulterating olive oil with cheaper vegetable oils and in selling the cheaper product under labels implying that it is olive oil. Repeated actions have been brought in an effort to control this type of violation.

Numerous prosecutions have been instituted against shippers of oysters and scallops who have adulterated their products with water, the cheapest and most prevalent of all adulterants.

The actions on colors have resulted from the sale of dyes represented as suitable for use in food which were either harmful in themselves or contained deleterious impurities, such as arsenic, or were mixed with large quantities of inert material having no coloring value, such as salt or sodium sulphate.

As in the past, tomato products have required much attention, owing to some manufacturers' practice of using rotten and decayed stock, or of adulterating with water or material made from tomato waste.

On July 1, 1920, the administration of the tea act was transferred from the customs division of the Treasury Department to the Bureau of Chemistry, together with the personnel of the customs division engaged in the work. This will result eventually in material economies, since the staff can be employed in the slack season of tea importations upon lines of work for which it is peculiarly qualified, such as the enforcement of those sections of the food and

drugs act which pertain to tea, coffee, and perhaps spices. A beginning has been made in the control of the misbranding of teas shipped in interstate commerce.

The service and regulatory announcements published during the year contained the text of the tea act, the new regulations for its enforcement, 36 opinions, and 2,200 notices of judgment. In cooperation with the Association of American Dairy, Food and Drug Officials, the compilation of State laws is still in progress and the compilation of administrative rules and regulations dealing with food products has been started.

Meetings have been held of the Association of Food and Drug Officials of the Southeastern States, of the Association of Food, Feed and Drug Officials of the South Central States, of the New England States Officials' Association, of the North Central Association of Food and Drug Officials, and of the Central Atlantic States Dairy, Food and Drug Officials' Association. The bureau's office of cooperation has assisted in the organization of a new group, the Association of Dairy, Food, Drug and Feed Officials, North Central States, comprising Minnesota, Wisconsin, North and South Dakota, Iowa, Nebraska, and Kansas. In this way the cooperative spirit has been fostered. During the year State officials instituted or assisted in the preparation of 263 cases under the food and drugs act, and municipal officers in 56. The distribution of these cases is shown in Tables 2 and 3.

TABLE 2.—*Actions instituted by State officials alleging violations of the Federal food and drugs act.*

State.	Prosecutions.			Seizures.		
	Food.	Feed.	Drug.	Food.	Feed.	Drug.
Alabama		5		4	1	
Arizona						1
Arkansas		2				
Florida	1	1			4	
Georgia		4		2	2	
Idaho				1		
Illinois	2	1		2		
Indiana		18		4	2	8
Kansas		47		2	1	1
Kentucky		10		4		1
Maine		4		8		
Maryland				2		
Massachusetts	1			1		
Michigan		15		4		1
Minnesota	3				2	
Mississippi		4				
Missouri			1			
Montana	1					
Nebraska				1		1
Nevada		2		4		
New Hampshire						1
New Jersey				15		
New York	1					1
North Carolina			1		1	
Ohio	1	3	1	6		8
Oklahoma						2
Pennsylvania		3				
Porto Rico				2		
South Dakota	1			3		
Tennessee		3		3		
Texas	2	3		2		8
Utah				1		
Virginia		2				
Washington				1		1
Wisconsin		1				
Total	13	128	3	72	13	34

TABLE 3.—*Actions instituted by municipal officials alleging violation of the Federal food and drugs act.*

Municipality.	Prosecutions.			Seizures.		
	Food.	Feed.	Drug.	Food.	Feed.	Drug.
Akron, Ohio	3					
Chicago, Ill.				3		
Cleveland, Ohio			1	1		1
Memphis, Tenn	1			2		
Richmond, Va	1					
Washington, D. C.	43					
Total	48		1	6		1

IMPORTED FOODS AND DRUGS.

As was the case last year, the variety and quantity of foods and drugs imported into this country during the present year have increased materially. The importations during the first half of the year were especially numerous. During the latter part of the year, however, the number and variety of shipments decreased. While many samples have been examined and many shipments detained because of adulteration and misbranding, little that was new or of special interest has been noted.

An increasingly large number of shipments of gelatin have been imported. When adulteration has been detected, indicating that the products were not suitable for food or drug use, release has been given after definite proof that the product would be used only for certain technical purposes. As happens each year, new adulterants and drug substitutes have occasionally been found. The number of medicinal preparations labeled with statements of curative or therapeutic effect examined has been especially large. When these statements were of a particularly gross and exaggerated nature, the goods were refused entry. In other cases release was allowed after suitable relabeling. The number and variety of shipments of mineral water entered during the present year have been large. Some were refused entry because of unsatisfactory sanitary quality. Most of them, however, were released either in the condition in which they were received or after the removal from the label of certain statements, particularly unwarranted claims as to their therapeutic value.

Attention has been paid to improving methods of import procedure, with a view to increasing, as far as possible, promptness and efficiency.

Table 4 gives the distribution of official samples examined by the field stations during the year, but does not include samples of thousands of shipments examined in a preliminary way.

TABLE 4.—*Report of field stations for year ended June 30, 1921.*

Laboratory.	Import samples.			Interstate samples.			Investigational samples.	Miscellaneous samples.	Total samples.	Hearings.	
	Floor inspection.	Released.	Detained.	Not adulterated or misbranded.	Adulterated or misbranded.	Check.				Import.	I. S.
Central district:											
Chicago	1,106	229	273	183	542	56	475	237	1,995	273	189
Cincinnati	11	118	21	100	365	8	198	70	880	26	163
Kansas City	6	25	2	.....	52	.....	6	.....	85	6	157
Minneapolis	105	38	11	51	80	93	340	192	805	11	38
New Orleans	46	83	46	44	287	19	132	16	627	48	212
St. Louis	32	45	14	124	460	48	427	777	1,905	15	128
Total	1,306	538	367	512	1,786	224	1,578	1,292	6,297	379	887
Eastern district:											
Baltimore	217	104	20	32	356	6	820	18	1,356	11	68
Boston	13,443	740	358	43	168	2	214	86	1,591	193	67
Buffalo	521	205	324	8	154	.....	101	208	1,000	261	130
New York	32,756	4,108	2,086	149	420	21	1,091	92	7,967	2,079	207
Philadelphia	1,336	234	170	17	78	5	278	10	792	127	72
Porto Rico	5,215	107	330	.....	30	.....	103	208	778	329	.....
Savannah	.....	99	32	13	128	11	302	6	591	21	63
Total	53,488	5,597	3,300	262	1,334	45	2,909	628	14,075	3,021	607
Western district:											
Denver	92	1	4	34	171	3	164	114	491	3	47
San Francisco	21,130	423	652	56	158	9	661	126	2,085	654	79
Seattle	4,280	77	106	104	101	.....	327	459	1,174	101	65
Total	25,502	501	762	194	430	12	1,152	699	3,750	758	191
Grand total	80,296	6,636	4,429	968	3,550	281	5,639	2,619	24,122	4,158	1,685

THE WATER AND BEVERAGE LABORATORY.

When the Federal food and drugs act first came into effect the labels of mineral waters bore the names of the most serious diseases, with positive corresponding claims of cures. Five years later it was a common practice to print upon the labels the names of serious diseases, introduced by "A remedy for," "A treatment for," "Used in," or some similar statement in place of "Cures." In 1912 or 1913, it was fairly generally believed that convictions in such cases would be very difficult to obtain. Since that time the bureau has come to regard these labels as constituting serious misbranding and has been so successful in maintaining this position before the courts that the presence of even the name of a disease upon the label of a mineral water shipped in interstate commerce is at present unusual and is considered of sufficient importance to warrant immediate investigation. Furthermore, during the latter half of the period elapsing since the passage of the food and drugs act so-called lithia waters which contained only the merest traces of lithium and which were alleged to be of the greatest therapeutic value because of their lithium content have been practically eliminated from the market. A somewhat similar situation with respect to mineral waters and other drugs alleged to contain radium, which threatened to develop to large proportions following the announcement that radium effected wonderful cures, was stopped before it had achieved much momentum through publicity and prompt action under section 10 of the food and drugs act.

At the same time, the sanitary quality of bottled mineral waters shipped in interstate commerce has steadily improved. For many years it has been a practice of the water and beverage laboratory to make careful inspection of mineral water sources, with a view to eliminating contamination at the points of origin. Important mineral spas in Missouri, Texas, Arkansas, Michigan, Kentucky, Iowa, and Wisconsin have been inspected repeatedly. Attention has also been given to many individual springs in Maine, New Hampshire, Massachusetts, Ohio, Kentucky, Tennessee, and other States. The problems involved in improving sanitary conditions are complex and require not merely thorough study but the education of the proprietors and frequently of the people forming the community as well. In some instances it is necessary also to instruct the city health officer and to obtain his cooperation and that of the mayor and council, as well as that of the State food officials. Much progress has been made. The protection of the springs from contamination and the methods of handling the water have been revolutionized in some places. Chlorinating, ozonizing, and other methods of purification have been installed, individual springs have been condemned and closed, and in general the proprietors of these places have come to realize the seriousness of certain conditions and are spending large amounts of money to remedy them. The problems involved are not completely solved, but they are well on the way to solution.

During and after the World War the sanitary condition of mineral waters imported from the countries at war was carefully controlled, for it was feared that owing to the establishment of encampments and hospitals at European spas such waters might have become contaminated and might introduce disease into this country.

In cooperation with the Bureau of Fisheries, several extensive investigations of tidal waters polluted by factory effluents in such a manner as to injure the shellfish industry of the neighborhood were conducted. It was possible in some instances to bring about the remedy of this condition.

In cooperation with the Bureau of Public Roads, the very serious deterioration of cement tile in certain drainage districts of the Middle West has been studied.

With the recent great increase in soft drink consumption, much work with this industry in improving sanitation and preventing adulteration and misbranding became necessary. Inasmuch as approximately 100,000 tons of cane sugar are used annually in these products, extensive experiments were conducted during the World War with a view to introducing the use of sugar substitutes. Formulas, including such wholesome sugar substitutes as glucose, maltose sirup, refiner's sirup, and corn sugar, were evolved. Some 30,000 copies of these formulas were distributed. It is believed that this was of tremendous advantage to the bottling industry, as well as an important factor in the war-time conservation of cane sugar.

For many years samples of salt containing barium appeared on the market and promised to become a menace to health. On investigation it was found that most of these samples came from the Pomeroy district of Ohio. A thorough study of the manufacture of salt in this district was therefore undertaken, and a process devised for the removal of barium from the brines produced there. The process, patented for the free use of the public, has been put into successful

operation by one of the largest salt producers of the district. The results of this investigation had a marked effect upon the salt produced in this district, as they called attention to the need of either special care in the technical control of the works or the installation of the treatment of the brine for the removal of the barium prior to the production of salt.

About 30 publications have been issued by this laboratory since 1913. During the fiscal year papers were published under the following titles: "Some Problems in the Manufacture of Beverages," "Acids in Beverages," " Bottles and Bottle Cleaning." Several others are in press.

THE MICROCHEMICAL LABORATORY.

The microchemical laboratory, like the water and beverage laboratory, is one of the staff laboratories which can not be relieved, for the present, of a large part of that regulatory work which, when purely chemical, is done by the field force. This is due to the scarcity of microscopists experienced in the methods of examining foods. Ultimately, however, it should be possible to train enough of them to supply the field force, leaving the microchemical laboratory free to devote itself exclusively to the staff work of supervising and planning field operations and conducting those investigations that lay a basis for the law enforcement, and to carry on educational and constructive work among producers.

The work of the laboratory bears in the main upon the detection of such adulterations of foods and feeds as require the use of a microscope. This usually involves the detection of the addition of some adulterant or the recognition that the food or feed was made from filthy, putrid, or decomposed material. In many cases chemical and bacteriological analyses fail and only the microscope is capable of giving the desired information. This is especially true for such finely ground foods as cocoa, ground spices, and cattle feeds, as well as tomato and fruit products made from decomposed stock. Without the work of this laboratory the control of such products under the food and drugs act would not be possible. It also conducts the microscopical work for the Insecticide and Fungicide Board, necessary in the enforcement of the insecticide and fungicide act.

This laboratory has devised methods for the detection in food products of decomposed beans, tomatoes, and fruit, for the estimation of cocoa shells in cocoa, cottonseed hulls in cottonseed meal, rice hulls in rice bran, powdered daisy flowers in insect powder, and mowrah meal in insecticides. It has made studies of insect powder, of domestic and imported veratrum (hellebore), and of calcium oxalate crystals in the drugs of the United States Pharmacopœia, and has worked out a microscopical method for determining the relative amounts of offal in flours as a basis for flour grading. It has done original work in applying optical crystallographic methods to the microscopical examination of foods, drugs, insecticides, and fungicides, as well as much constructive and educational work among producers of certain types of foods, one result of which has been the elimination to a large extent of certain extremely objectionable practices in manufacturing and handling tomato products. Studies of

the microchemistry of alkaloids, for the purpose of their identification, have been made.

Since, with the exception of bacteriologists, pathologists, botanists, and zoologists, the staff of the microchemical laboratory represents probably the only group of experienced general microscopists in the Government service, it is called upon by other departments, particularly the Post Office and War and Navy Departments, to examine a wide range of materials. Its help is solicited especially in the determination of the kind and character of the fibers found in various textiles, including twines and ropes, in which field it has had much experience.

It has served as a training school for microscopists, especially those engaged in official work in the States, but also occasionally for those employed by manufacturers. This year six feed-control officials, including two from Canada, received such training.

THE MICROBIOLOGICAL LABORATORY.

In the utilization of agricultural products the fermentation industries play an important rôle. Fermentation and spoilage are important factors in the waste and deterioration of agricultural products. In the enforcement of the food and drugs act it is necessary to take cognizance of the spoilage of foods, since such foods, so far as they are "filthy, putrid, or decomposed," are declared by that act to be adulterated. A laboratory specializing in the study of the problems of the fermentation industries and in the study of the causes of food spoilage did not exist in this country prior to 1913, when the bacteriological laboratory of the bureau was converted into a laboratory of microbiology devoted to such studies.

OYSTERS.

In cooperation with the bacteriologists of the United States Public Health Service, this laboratory has made sanitary surveys covering practically every oyster-producing area on the North Atlantic seaboard. Special reports were prepared upon Narragansett Bay, Long Island Sound and its approaches, Jamaica Bay on Long Island, New York Harbor and the adjacent New Jersey waters, the Maurice River in New Jersey, Chesapeake Bay, and the Potomac River. The extent of sewage pollution in these areas was carefully determined and the limits within which oysters could be grown and marketed without danger to the public health were established. The industry was notified from time to time of these findings. While in a few exceptional instances the trade resisted, general compliance with these reasonable limitations has vastly improved the sanitary quality of the oyster supply.

Studies of the washing of oysters, covering a period of years, have shown the conditions under which oysters contaminated at the point of production may be purified so as to be safe for sale. It has thus been possible to specify, within easy reach of oyster-consuming centers, clean waters in which proper exposure for periods varying from 24 hours to a week would bring most lots of shellfish to proper condition. However, a recent adaptation by the United States Public Health Service, cooperating with the Bureau of Chemistry, of the use

of hypochlorite as a purifier may in time displace the transplantation method of purification.

The freedom of oysters from evidences of pollution during the cold weather has been fairly well established by studies of their hibernation. The temperature limits for the waters which bring oysters in polluted areas to a condition in which they are no longer dangerous have been determined. Establishment of this condition for particular areas season by season made permissible the marketing of oysters from many areas that otherwise would have been closed.

MILK, EGGS, AND BUTTER.

In cooperation with the Bureau of Animal Industry and with the field force of the Bureau of Chemistry, systematic campaigns were conducted to eliminate from interstate commerce shipments of milk and cream either highly contaminated with bacteria or in which incubation had produced enormous numbers of organisms. These campaigns involved not a little scientific research and much education of producers, shippers, and distributors in proper methods of handling this important perishable. The result has been an appreciable improvement in the quality of the milk supply in a number of cities, notably in New England and the Mississippi and Missouri valleys.

In order to keep from interstate commerce decomposed frozen eggs unfit for food, chemical and bacteriological studies upon the decomposition of eggs were made. Data which make it possible to determine whether a given lot of frozen eggs is fit for food were obtained. This information has been applied in the enforcement of the food and drugs act.

A similar investigation of the materials used in the manufacture of butter is still in progress, the microbiological laboratory and the office of food control cooperating. A method has been devised to make it possible to determine from the analysis of a market sample of butter whether or not it has been manufactured with a neutralizer.

SARDINES.

With the growth of the canned sardine industry of Maine carelessness in dealing with the fish developed, as a consequence of which some decomposed fish were included in the pack. Bacteriologists and chemists of the bureau cooperated in studying conditions, and in 1921 Department Bulletin 908, "The Maine Sardine Industry," was published. Recommendations were made to the packers, which many accepted gladly. The minority were forced to change their methods through the application of the provisions of the food and drugs act. The net result was a cooperative organization of the packers for the purpose of policing themselves. Thus the bureau succeeded in establishing a most important precedent, which has since been followed in other industries. Obviously the ideal condition is for an industry to police itself so effectively that Government interference is unnecessary.

COMMERCIAL BOTTLED WATERS.

In connection with the work of the water and beverage laboratory, the bacteriologists of the bureau made an elaborate study of the

microorganisms found in commercial bottled waters and of the longevity of these organisms under the conditions prevailing in the commercial handling of such bottled products. It was shown that a clean water might be seriously contaminated by the methods of handling in the bottling establishment, so that the product appearing in interstate commerce was distinctly bad, and also that many supplies which were used in the production of bottled waters were contaminated at the source. Furthermore, it was shown that natural or artificial carbonation materially affects the flora of particular waters. It was found that carbonic acid, as used in the carbonation processes, was very effective in the highly purified types of water in destroying the organisms associated with pollution, but less efficient in the case of water in which high salt contents of certain types occurred.

FERMENTATION STUDIES.

The peculiar bacterial flora of salted products has been studied. The microbiological laboratory has made a number of fermentation studies. Thus it has shown that the many failures of sauerkraut manufacturers result from an attempt to ferment cabbage at a temperature too low to permit of the normal development of the lactic-acid-producing flora. Methods devised to control the temperature at which the shredded cabbage goes into the sauerkraut vat have proved a practical solution of this difficulty under factory conditions. In pickle fermentation a difficulty arises from the cucumber's deficiency in sugar. The lactic-acid-producing flora therefore does not automatically dominate the fermentation unless especially favorable conditions are created for it. The cucumber is naturally so contaminated with soil as to produce an extensive infection of the pickle vat. It was found by experiment that brine strong enough to control the organisms which soften and destroy the cucumber must contain at least 8 per cent of sodium chloride. In this fermentation, the necessity of strict control to obtain a normal product free from spoilage has been clearly established.

In cooperation with the States Relations Service, the possibility of utilizing some kinds of excess fruits or vegetables in small lots for the production of vinegar for local use has been demonstrated and information concerning the methods used disseminated widely throughout the Southern States.

The possibility of using excess potatoes for cattle food in the form of silage was developed in Germany some years ago. The German practice consisted primarily in grinding the potatoes and placing them in trenches in the ground. Large losses were the rule rather than the exception. In carefully controlled experiments it was shown that the introduction of freshly ground corn meal to an amount equaling or exceeding 1½ per cent of the potatoes used would insure a prompt and efficient souring of the entire mass. In this way the losses, which often reach 50 per cent in the German practice, could be cut to practically nothing.

Increasing quantities of oriental food products produced by specific types of fermentation are being imported. Perhaps the most important of these is soy sauce. While these products are not of great commercial importance, they enter into so many special food

products in the form of sauces that a sound knowledge of the conditions surrounding their production is eminently desirable. Moreover, information which would make it possible to produce them in this country should be made available. Soy fermentation has been studied and the methods of producing soy sauce mastered. Studies upon the Japanese product "miso" and upon Chinese red rice, or "ang khak," produced with the aid of *Monascus purpureus*, are in progress.

FOOD POISONING.

The recognition of botulism in the United States, due to the work of Dickson in California about 1914, furnished the basis for instituting in the bureau a study of food poisoning. The work thus far has been limited largely to the study of the type of poisoning represented by the activity of the *Bacillus botulinus*. Two years of fundamental work were done in the laboratory, with the cooperation of the Bureau of Animal Industry, before it became generally recognized that foods coming within the jurisdiction of the food and drugs act might produce botulism. Studies in this laboratory have shown that the presence of this organism has caused poisoning from eating canned asparagus, canned olives, and canned spinach. Every effort has been made to establish as fully as possible the character of precautions necessary to protect the consuming public from the danger of this type of poisoning, and the information has been disseminated widely.

The importance of food poisoning which shows itself in violent enteric symptoms without the great mortality found in botulism has led to an investigation of the enteritidis group of organisms. In this case the laboratory is still laying foundations as it did in its study of *Bacillus botulinus*.

MOLD FLORA.

The laboratory has been carrying on a continuous study of saprophytic molds responsible for spoilage and fermentation. So far as possible, a careful survey of the mold flora of every food product coming into the bureau for inspection is made. Thus, in time, full information concerning the normal flora of many kinds of food will be accumulated. In the course of this work a large collection of organisms has been gathered and from this collection authentic material is furnished to investigators the world over.

PUBLICATIONS.

Papers covering a series of organisms important in fermentation and spoilage problems have been issued. These include the group centering upon the species *Aspergillus niger*, which has formed the basis of the commercial production of citric acid and includes strains occurring constantly in all sorts of foodstuffs, one centering on *Aspergillus fumigatus*, which appears as a pathogenic organism in the aspergillosis of birds and occasionally of man, and *Aspergillus flavus*, *A. oryzæ*, and associated species. Other contributions made during the year appeared under the following titles: "A Bacteriological Study of Canned Ripe Olives," "The Flora of Corn Meal," "The Possible Pathogenicity of *Bacillus Botulinus*," "The Decomposition of Feedy Salmon," "Bacterial Decomposition of Salmon,"

"Bacterial Groups in Decomposing Salmon," "The Identity of *Aspergillus Oryzæ*," "The Relation of Mosaic Disease to the Pickling of Cucumbers." The following papers are in press: "Mold Hyphæ in Sugar and Soil Compared to Root Hairs," "Trehalose Fermentation in the Differentiation of the Paratyphoid-enteritidis," "The Story of Sauerkraut and Its Production."

THE CATTLE FOOD AND GRAIN INVESTIGATION LABORATORY.

The work of the cattle food and grain investigation laboratory deals in the main with the control of the adulteration and misbranding of feeding stuffs, its investigations furnishing the basis for the work of the field force upon feeds. It has cooperated with the Association of Feed Control Officials of the United States in the establishment of definitions for the feeding stuffs in common use, and has studied the milling of rice and the crushing of cotton seed, copra, and peanuts. With a view to their utilization as feed, certain waste products, such as olive pomace, almond hulls, fruit and vegetable cannery waste, mesquite beans, and various waste seeds, have been investigated.

This laboratory has made physical and chemical studies of the kafir kernel as a first step in the development of wider uses for the grain sorghums. In cooperation with the Bureau of Plant Industry, it has determined the composition of many of the native pasture grasses of the United States. It has responded to many calls to conduct analyses for various branches of the Government, and has done extensive work on the standardization of analytical methods, especially for moisture and fiber determinations.

THE PHARMACOGNOSY LABORATORY.

The pharmacognosy laboratory was established in 1914 for the purpose of supervising the control over crude drugs exercised by the field force under the food and drugs act and for the conduct of such pharmacognosy investigations as are required for the efficient enforcement of the law or are designed to prevent waste or improve the utilization of crude drug products.

This laboratory considers appeals from the decisions of the field force in the case of crude drug importations and makes appropriate recommendations to the administrative officers. In this connection it has encouraged the introduction of new crude drugs or of new sources for well-known drugs whenever this seemed useful. It has made a survey of the crude-drug gathering industry of the southern Appalachian region, and has contributed much to the standardization of crude drugs for purity, especially with reference to acid-insoluble ash as an index of cleanliness. It has studied volume-weight determinations as a means for the rapid detection of inferiority, and is taking an active part in the work of revision of the United States Pharmacopœia and National Formulary. To facilitate the identification of crude drugs a large collection of authentic samples, comprising a great number of plant products from all parts of the world, has been accumulated. The catalogue of this collection has been distributed to the field laboratories of the bureau and to the curators of other similar collections. Many new forms of sophistication have been discovered and described.

The pharmacognosy investigations include studies upon cyanogenesis and the determination of hydrocyanic acid, upon the occurrence of oxalic acid in crude drugs, upon saponins from various sources, upon *Simaba cedron*, *Piper bredemeyeri*, Veratrums, Viburnums, Hydrastis, Ipecacuanha, Salvias, Zamia, *Solanum macrocarpum*, Calocarpum, mammosum, Brassica, and beans of the Lima type. The studies upon Brassicas have made possible their classification into products suitable and unsuitable for mustard, so that the range of seeds adapted to condimental purposes has been extended. A simplification of the method for the determination of their volatile oils has been introduced. Methods for the differentiation of tropical beans of the Lima type from ordinary navy beans have been described and the range of the amount of hydrocyanic acid occurring in Lima type beans determined. Tropical beans of this type offered for importation during the war-time bean shortage contained harmful amounts of hydrocyanic acid and were excluded from the country.

Work has been done on the improvement of methods of cleaning crude drugs by washing, flotation, sifting, blowing, scraping, and other means based on differences of density, size, shape, or consistency.

In connection with the boll-weevil investigations of the Bureau of Entomology the cotton plant was studied. The distribution over the plant of the oil glands was determined and a volatile oil decidedly attractive to boll weevils separated.

An investigation of the value of microsublimation in food and drug analysis is in progress.

THE DRUG DIVISION.

The drug division conducts research work required in the enforcement of the food and drugs act, in so far as it applies to drug products other than crude drugs. This consists mainly of analytical methods for the quantitative estimation of substances used as medicines but also includes studies upon the methods of manufacturing medicinal products. For example, extensive investigations have been made upon the methods of manufacturing the various types of tablets. Among the materials for which analytical methods have been developed may be mentioned Peru balsam, aromatic spirits of ammonia, spirits of nitrous ether, santonine, paregoric, papain, pepsin, antipyrine, acetylsalicylic acid, phenacetin, salol, pyramidon, theobromine, hexamethylene tetramine, monobromated camphor, and guaiacol. This division has also done much work upon essential oils, such as chenopodium, sassafras, wild mustard, anise, fennel, clove, and pimenta oils.

It cooperates in the revision of the United States Pharmacopœia and assists the Post Office Department in closing the mails to persons or firms doing a fraudulent business in the sale of medicines and related products, and of therapeutic and similar treatments sent by mail, thus reaching many frauds which can not be touched by the food and drugs act.

THE PHARMACOLOGICAL LABORATORY.

In connection with the enforcement of the food and drugs act, the pharmacological laboratory conducts investigations to determine

whether substances that have been added to or that contaminate foods may be deleterious to health and considers also the potency of drugs. Among the substances studied are caffeine and some of its isomers, saponins, tartrates, citrates, malates, succinates, oil-soluble dyes, some of the heavy metals, especially tin and zinc, iodine, and iodides.

This laboratory has also carried on a series of pharmacological or toxicological studies, in part independently, in part in cooperation with other bureaus, upon a variety of subjects important in the prosecution of various lines of work of the Department of Agriculture. For example, in cooperation with the Bureau of Biological Survey, studies have been made with a view to developing more efficient rat poisons. The toxicity of cotton seed and cottonseed meal has been investigated. From this laboratory came the warning to physicians treating the hookworm disease that the vermifuge chenopodium oil is so toxic as to require great care in its therapeutic administration. The chemical composition of this oil was thoroughly investigated and steps taken which it is hoped will lead to the substitution of ascaridol, the active principle of the oil, for the oil itself. This should make more exact dosage possible and lessen the chance for fatalities.

During the fiscal year 1920–21 there were published Department Bulletin 915, "Toxicity of Barium Carbonate to Rats," as well as the following papers: "A Comparison of the Effect of Certain Saponins on the Surface Tension of Water with Their Hemolytic Power," "Some Observations upon the Behavior of a Fixed Oil (Peanut Oil) Injected Intraperitoneally."

Work on the effect of strychnine upon rats has been completed. The work on arsenic has been extended, with results of importance in connection with the use of this poison as a vermin exterminator, and in connection with its occurrence in food. Some of the results seem to throw doubt on much of the reported work on "habituation" to arsenic.

The investigation of poisoning by cotton seed has made progress. The occurrence of gossypol, the toxic principle, in different samples of cotton seed was studied. It was found that a seasonal variation could occur in the same variety of cotton, that seed tending to run high in oil and low in protein usually runs high in gossypol, and vice versa. That variety rather than locality of production influences appreciably the gossypol content of cotton seed could not be proved. The variation of the gossypol content found in different specimens of seed was about 300 per cent. By animal feeding experiments it was demonstrated that the toxicity of a given sample of seed is approximately proportionate to its gossypol content. The symptoms produced do not differ from those resulting from the administration of comparable doses of pure gossypol. In chronic intoxications the nervous system (paralyses), the circulation (œdema of the lungs), and the metabolism (negative nitrogen balance) are affected. In acute intoxications gossypol is a cardiac poison, producing œdema of the lungs with congestion and, in suitable dosage, a red running of the nose.

During the year studies upon intoxication with zinc and upon the chronic intoxication with small amounts of cadmium were completed. Studies upon the toxicity of aliphatic alcohols, and alkyl

esters were begun. These are needed in determining the bureau's policies with reference to the use of certain synthetic flavoring substances.

THE CARBOHYDRATE LABORATORY.

The work of the carbohydrate laboratory since 1913 may be divided into four categories: The determination of the physical and chemical properties of the sugars and their derivatives; the improvements of the methods of preparing the rare sugars; the study of methods for the analysis of sugar-containing products; and work on improving methods of manufacturing sirups, sugar, and carbohydrate-containing products.

SUGARS.

The work on the constitution, the mutarotation, and the rotatory power of sugar and sugar derivatives, and on the action of enzymes upon sugars has won international recognition for the laboratory. Two new sugars, containing seven carbon atoms in the molecule, the first of their type occurring in nature, were discovered. Many of the methods originated by the laboratory for the preparation of rare sugars are now in commercial use. Certain rare sugars that were formerly chemical curiosities have been made available to investigators. Rare sugars not procurable in commerce are distributed to bacteriologists and others. Methods have been devised for the estimation of cane sugar by means of an enzyme from yeast, for the analysis of maple sugar and sirup, of sorghum sirup, of honey, and for the estimation of raffinose.

SUGAR AND SIRUP MANUFACTURE.

The work carried on for some years prior to 1917 to produce more powerful decolorizing carbons for use in sirup and sugar manufacture proved the starting point for the production of carbons used in American gas masks during the war. Since the war the laboratory has continued work on the use of such carbons in sirup and sugar production. Improvements have been introduced in the manufacture of maple products, of cane and sorghum sirup, and of jams, jellies, and preserves, while some of the problems of the confectionery industry have been studied.

In continuation of the work on methods for preparing better quality sugar-cane sirup, the following publications were issued and sent out to the sirup producers in advance of the cane-grinding season of 1920: Department Bulletin 921, "Sugar-Cane Juice Clarification for Sirup Manufacture;" Department Circular 149, "Cooperative Cane-Sirup Canning;" and "Manufacture of Sugar-Cane Sirup so as to Prevent Crystallization and Fermentation."

In order to demonstrate the invertase method for making sirup of improved keeping quality, a considerable amount of invertase, prepared from yeast in the laboratory, was furnished to cane-sirup producers who expressed an interest in the process, and a chemist was sent south to assist the sirup producers in the use of this method. Cooperative work with several cane-sirup manufacturers was conducted for the purpose of comparing various methods of clarification.

Cooperative work was conducted with several cane-sugar producers for the general purpose of investigating existing factory problems, the ultimate object being to improve present practices. A paper on "The Use of Kieselguhr for the Clarification of Cane Juice," comparing the physical and chemical properties of various grades of this material and their corresponding clarifying efficiency, has been prepared for publication. Experimental work was conducted in Louisiana to compare the existing sulphur-lime method of clarification with a more recently proposed process, in which kieselguhr and decolorizing carbon are employed. The results of part of this work are given in a paper entitled "An Investigation of the Composition of the Sirup Precipitate Obtained in the Manufacture of Cane Sugar by the Use of Kieselguhr and Decolorizing Carbons."

Studies in beet-sugar technology from a chemical standpoint are being carried out in the field in cooperation with beet-sugar factories. This investigation has for its object the critical study of various impurities derived from the beets and the determination of the rôle played by these impurities in certain factory troubles. The work so far undertaken includes a study of raffinose and methods for its determination, the character and amount of colloidal material (including gums) present in diffusion juice obtained from beets under various conditions, the character and amount of colloidal material present in various beet-sugar house liquors and products, and the part played by such colloidal material in sugar-house processes. The following papers have been prepared for publication: "A Study of Beet Gum: I. Preparation from Final Molasses" and "Colloids in Beet-Sugar House Liquors and Products."

The method for the production of an edible sirup from sweet potatoes discovered by the bureau in 1919 has been perfected and the commercial development of the process undertaken on a semimanufacturing scale in Georgia. Cost data and operating details are being learned. The outlook for the establishment of a small sweet-potato sirup industry is promising.

STARCH.

Studies have been made on the manufacture of starch from such sources as the white potato, the sweet potato, and the grain sorghums.

UTILIZATION OF CORNCOBS.

The work upon the utilization of corncobs, which has been in progress for some years, has passed into the semicommercial development stage. Methods of increasing the yields of furfural have been devised, so that it should be possible to produce relatively cheaply this aldehyde, useful as a solvent for resins and varnishes, as a paint remover, and in the production of condensation products of the bakelite and condensite type.

PUBLICATIONS.

In addition to the publications previously mentioned, the following were completed during the year: "Crystalline Chlorotetracetyl Fructose and Related Derivatives," "Sedoheptose, a New Sugar from *Sedum Spectabile*," "Volemite," "Cellulose Phthalate: Its Preparation and Properties," "Improvement in Sirup Manufacture,"

" The Preparation of Rhamnose," " Optical Properties of a Series of Heptitols," " Occurrence of Diastase in the Sweet Potato in Relation to the Preparation of Sweet Potato Sirup," "A Practical Study of Corncob Utilization," "A Precipitate Obtained from Cane Juice After Clarification with Kieselguhr and Decolorizing Carbon," " The Effect of Some Decolorizing Carbons upon the Color and Colloids of Cane Juice," " The Effect of Varying Hydrogen Ion Concentration upon the Decolorization of Cane Juice with Carbon," " The Preparation of Sweet Potato Sirup."

THE OIL, FAT, AND WAX LABORATORY.

Before 1918 the oil, fat, and wax laboratory conducted investigations upon the improvement of the methods used by oil analysts upon the composition of oils, fats, and waxes, and upon technological problems important to the oil and fat producing industry. It also cooperated with the Bureau of Plant Industry and the Bureau of Markets in determining the variations in quality and quantity of the oil obtainable from a number of oil seed crops dependent upon the variety of the plant grown and the locality. Such studies were made especially in the case of the soy bean and the peanut. In part through the efforts of this laboratory, cooperating with other bureaus of the department, a small-scale virgin peanut oil industry became established. An efficient battery of extraction apparatus for the determination of oil by extraction with volatile solvents was designed and introduced. In cooperation with the Food Administration, Department Bulletin 769, " The Production and Conservation of Fats and Oils in the United States," the first survey of the whole oil and fat industry, was issued.

Since little of importance concerning the actual composition of oils, even those like cottonseed which has been of great commercial importance for many years, was recorded, it was determined in 1918 to undertake the systematic research necessary to supply this information of fundamental importance to the oil-producing and oil-consuming industries, especially to hydrogenators of oils and to soap makers. Among those studied are cottonseed, peanut, tomato seed, okra seed, Hubbard squash seed, and cantaloupe seed oils. In the course of this work a small amount of myristic acid was detected in cottonseed oil, and the presence in this oil of both stearic and arachidic acid definitely proved. Moreover, an extensive investigation of the influence of the locality of production of the seed upon the composition of the oil obtained from it was made. Contrary to the indications from previously published analyses, the results showed that the chemical and physical characteristics of the oils from seed grown in different localities of the cotton belt are remarkably uniform. A study of the composition of Spanish and Virginia peanut oils has been nearly completed.

During the year 1920–21 the following papers were submitted for publication: " Okra Seed Oil," " The Composition of Hubbard Squash Seed Oil," " The Composition of Cottonseed Oil," " Cantaloupe Seed Oil," " The Influence of Geographic Source of Seed on Cottonseed Oil," " Note on the Titer of Authentic Samples of Cottonseed Oil," " The Analysis of Otoba Butter," " Menthol and Phenyl-

hydrazine Derivatives of the Higher Fatty Acids," "Methods for the Examination of Cacao Butter."

THE CITRUS BY-PRODUCTS LABORATORY.

The citrus by-products laboratory was established at Los Angeles, Calif., in 1914, for the purpose of devising methods for the utilization of cull oranges and lemons. It has been an important factor in the establishment of the manufacture of citric acid, lemon oil, orange oil, marmalade, and candied peel in California and has done work looking to the same end in Florida. A method has been evolved for the manufacture of a high-grade orange vinegar, and studies looking to the improvement and standardization of the methods of sweating lemons are in progress. Two important problems, however, still remain to be solved. One is the invention of a method for the production of lemon oil of the same composition as the hand-pressed oil of Sicily, as the oil now being produced is often deficient in certain valuable ingredients. The other is the discovery of a satisfactory method for the preservation of orange juice.

The laboratory made an important study of the chemical changes that take place in oranges and grapefruit during ripening as the result of which definite standards of maturity were proposed so as to make it possible through procedure under the food and drugs act to keep unpalatable immature fruit from the market. This has been of great benefit to honest producers, and the bureau's standards of maturity for oranges and grapefruit have been enacted into law in California and Florida.

The laboratory has become the consulting chemical branch of the Department of Agriculture for much of the research that is going on in California. In cooperation with the Bureau of Plant Industry, it has determined the variations in composition of oranges, lemons, and grapefruit, dependent upon variety, soil, and location. For purposes of propagation, in connection with that bureau's investigations on bud variation, it has studied the composition of the fruit of individual selected trees. The purpose of all this work is to improve and standardize by rational selection the varieties grown. In cooperation with the same bureau and for similar purposes, it has studied the composition of avocados. In cooperation with the Bureau of Markets, it has studied, both in California and Colorado, the chemical changes that take place in the ripening of cantaloupes for the purpose of improving the criteria used in determining when they are in the best condition for shipping.

THE FOOD RESEARCH LABORATORY.

The food research laboratory, organized originally to develop criteria for judging food products subject to the food and drugs act held in cold storage, soon grew into an important constructive service to the poultry and egg-handling industry of the country. It determined what chemical changes take place in poultry and eggs when held in cold storage for short and long periods. It developed and introduced into general use more efficient and sanitary methods of killing, bleeding, picking, chilling, freezing, and packing poultry. It studied the causes of the deterioration of shell eggs and proposed

remedies which have been widely adopted. It introduced improved methods of candling, chilling, handling, and transporting eggs. It studied the breakage of eggs in transit and the suggestions it has made with reference to the flats and fillers for egg cases, to the construction of eggs cases and their stowing and bracing in freight cars, and to the switching of freight cars in the yards have contributed materially to the reduction of a great economic loss. It has revolutionized the egg-breaking industry of the country. It introduced improved and more sanitary methods in the egg-drying industry before this business was transferred by American firms to China. It studied refrigeration in transit, the efficiency of refrigerator cars, and methods of icing them. Its recommendations have been adopted widely by the railroads and many of its suggestions are embodied in present-day refrigerator rolling stock design. This laboratory was peculiarly successful in translating its discoveries into everyday practice.

In 1914, following an understanding with the Bureau of Fisheries, the food research laboratory undertook work upon the handling, transportation, and utilization of sea foods analogous to that it was doing upon poultry and eggs. It determined the food value of fish, the chemical composition of which was unknown. It studied the changes in food value of fish dependent upon size, condition, and season, methods of icing, freezing, and transporting fresh fish and of preserving them, such as salting, smoking, kippering, and canning, the changes frozen fish undergo in cold storage for long and short periods, and the utilization of fishery by-products. It succeeded, especially during the war, in widening the consumption and in organizing the more rational distribution over the railroads of fish, particularly from the Gulf of Mexico. As in the case of the handling of poultry and eggs, so the work of this laboratory represents almost the first fundamental scientific work upon the American fish-handling industry.

No money has been appropriated for the continuation by the bureau after July 1, 1921, of either the poultry and egg work or the fish work. Therefore at the close of the fiscal year the work was stopped, the food research laboratory closed, and its staff disbanded.

THE LABORATORY OF DEHYDRATION.

In connection with the development of the bureau's utilization program, outlined in the introduction to this report, attention was given to the preservation of fruits and vegetables by drying, in the belief that this method is destined some day to play an important rôle in the country's food-preserving industry. At first the work was carried on in the fruit and vegetable utilization laboratory, where investigations were made upon the relation of moisture content to keeping qualities of raw dried vegetables, upon the effect of heat on different dehydrated vegetables, upon the preparation and keeping qualities of dried soups, and upon the keeping qualities of steam-blanched potatoes.

During the war the subsistence division of the Quartermaster Corps looked upon the fruit and vegetable utilization laboratory as the real source of information on dehydration. The corps inspectors were sent to the bureau for instruction before going out to dif-

ferent plants to supervise the manufacture of materials for the Army. Contractors for the Army received advice and instruction, especially in the drying of potatoes. The standards for the dried vegetables contracted for by the United States Army were the result of information furnished the Quartermaster Corps. The bureau insisted on a moisture content of 10 per cent or less for all products at that time and also advised blanching if the moisture content was much above 7 or 8 per cent. In the case of potatoes, which must be either blanched or sulphured to preserve the color, the bureau took a firm stand against sulphuring. Largely as a result of this stand, no dehydration plants are attempting to sulphur vegetables at the present time. The bureau was able to recommend heat limits in drying for some products, such as potatoes, and to give advice on steam blanching. It is noteworthy that the potatoes produced for the American Army were greatly superior in quality to any of those produced by the Canadian plants. At the time of the signing of the armistice the drying plants of the United States were putting out dried potatoes of excellent quality, which have not yet been surpassed.

During the war Congress made a specific appropriation for the conduct of work to promote the industry of dehydrating fruits and vegetables, making possible the establishment of a special laboratory of dehydration. Since the armistice was signed both laboratory and field investigations have been conducted with a view to improving the quality of the commercial products. The industry requires much research work before uniformly good products will be found universally upon the market. Each fruit or vegetable presents specific problems which must be studied to find the answers to such questions as which is the best variety for dehydration purposes, at what temperature and with air of what humidity should it be dried, what preparatory treatment, such as blanching, should it be given, to what degree should its moisture content be reduced, and how should it be packed, handled, and stored. A series of years will be necessary to complete the investigations of this character now in progress.

Studies on the best design of plants and on the costs of operation are also necessary. Such studies on fruit artificially dried in California as compared with the sun-dried, sulphured fruit, have been made and published. It is hoped that the results, which were not unfavorable to artificial drying, will help to hasten, in the case of some fruits at least, the substitution of artificial drying for sun drying which is subject to the hazards of the weather and which, in many cases, produces a less desirable product. In Oregon and Washington, where the climate is unfavorable to sun drying, this matter is vital to the fruit industry, and there the bureau is doing cooperative work with the local agencies. In cooperation with the Bureau of Plant Industry, the Bureau of Chemistry has also been of assistance in establishing the drying of raisin grapes in California. Furthermore, methods have been devised for the improvement of the process for making potato flour.

Men trained in the principles of food chemistry and engineering have visited most of the commercial plants, where they have often been able to be of assistance. For example, an engineer connected with the work studied conditions in one plant, securing such information that the management was encouraged to make alterations

enabling it to add 50 per cent drying capacity to the tunnels without any additional radiation. According to a census taken in cooperation with the University of California, 148 drying plants, employing many types of equipment, were operating in California during the past season. Studies on these driers have been made with a view to determining which is the most efficient for each crop. The majority of these drying plants are of small capacity, and the owners or managers are not always adept in their operation, nor can they afford to employ expert help. The bureau's representatives have been able to assist them in many ways.

As important as improving process and products in establishing the dehydration industry on a firm basis is the creation of a market. Though many of the dehydrated products are excellent, the public is slow to use them because ignorant of what may be expected of them. Therefore, a special campaign has been conducted by the bureau to acquaint the public with their value. Samples of dehydrated foods were sent to hotels, hospitals, schools, clubs, and restaurants for personal test, with the request that the results be reported. Replies received by the bureau indicate that the dehydrated products were considered satisfactory and the campaign gave very encouraging results. A large number of letters requesting specific information concerning dehydration were received, and appropriate information forwarded. A number of popular articles were prepared for publication in journals, magazines, and newspapers.

During the year 1920–21 the following reports were submitted for publication: "The Mineral Constituents of Potato Flour: Effects of Process of Manufacture on Composition of the Ash of Potato Flour," "Effect of Heat on Different Dehydrated Vegetables," "The Manufacture of Sweet Potato Flour by the Flake Process," "The Relation of Moisture Content to the Deterioration of Raw-Dried Vegetables upon Common Storage," "Methods of Preparing Vegetables for Dehydration—Potatoes, Carrots, and Cabbage," "Sun Drying Versus Dehydration."

THE PROTEIN INVESTIGATION LABORATORY.

For some time it has been known that only certain proteins are capable, unsupplemented, of furnishing all the necessary nitrogenous constituents of the diet. Others must be supplemented by the addition of those ingredients in which they are deficient, if they are to be utilized efficiently by animals. It is therefore of great economic importance to know in what manner a given protein is deficient in order that in feeding animals its deficiencies may be compensated for and wasteful methods of feeding avoided. Such knowledge which has been lacking for many of the most important food proteins is now available in the protein investigation laboratory. Since its establishment in 1915 this laboratory has put out 33 scientific communications bearing upon this general subject.

Among the proteins studied are those of barley, kafir corn, the peanut, buckwheat, several species of beans, and tomato seed. Incidentally, the methods of making such studies have been improved. Information thus obtained has been applied in feeding experiments either upon laboratory animals or, in cooperation with the Bureau of Animal Industry, upon farm animals. The reasons why some of

these foodstuffs are not satisfactorily utilized have been disclosed and the remedy shown in a number of instances. For example, it was found that, while the protein of wheat flour is not very satisfactory in promoting growth, bread made from a mixture of 15 parts of soy bean meal and 85 parts of wheat flour furnishes protein and water-soluble vitamine adequate for normal growth. Certain other materials, for example, peanut meal, may be used instead of the soy bean meal. For somewhat similar reasons ordinary beans are not a very satisfactory source of the necessary nitrogenous elements of diet. However, if cooked and supplemented with the sulphur-containing substance cystine, or a protein containing much cystine, they become an excellent source of food protein. Similar studies have been made upon the best methods of supplementing such important feedstuffs as corn and corn gluten.

In addition, the protein investigation laboratory has studied the effect upon animals of the addition to the diet in minute quantities of certain heavy metals that may contaminate ordinary foods—information of service in the enforcement of the food and drugs act.

During the current year the laboratory has presented or has sent to press the following reports: "The Nutritive Value of Peanut Flour as a Supplement to Wheat Flour," "Some Amino Acids from the Globulin of the Coconut as Determined by the Butyl Alcohol Extraction Method of Dakin," "Hydrolysis of the Globulin of the Coconut," "Some Proteins of the Mung Bean, *Phaseolus aureus*," "The Globulin of the Cohune Nut," "The Effect of Cooking on the Digestibility of Phaseolin," "The Nutritive Value of Soy-Bean Flour as a Supplement to Wheat Flour," "The Nutritive Value of the Proteins of the Lima Bean," "The Nutritive Value of the Proteins of the Adsuki Bean," "The Basic Amino Acids of Glycinin, the Globulin of the Soy Bean, as Determined by Van Slyke's Method," "The Nutritive Value of the Proteins of Tomato Seed Press-Cake."

Work upon the effect of small quantities of cadmium in the diet and upon the nutritive value of the proteins of the Chinese and Georgia velvet beans has been completed.

In progress is an investigation on the composition of the milk protein, lact-albumin, of the two globulins of the Adsuki bean, of the proteins of the navy bean, the palm kernel, and the Lima bean, and of the globulin of the soy bean. An attempt is being made to explain why arachin, the chief protein of the peanut, does not produce satisfactory growth in rats when fed as the sole source of protein and why the nutritive efficiency of the proteins from the Chinese and Georgia velvet bean depends in part upon the method of preparation.

Among the investigations upon nutrition now engaging the attention of the laboratory the following may be mentioned: Work upon the cowpea, *Vigna sinensis*, indicates that cooking and the addition of cystine are necessary to render this food adequate for the normal growth of albino rats. With the ordinary pea, *Pisum sativum*, however, it is probable that growth can be obtained when it is fed cooked or uncooked with the other nonprotein dietary ingredients. Cystine is not required, as in the case of the seeds of the genus Phaseolus. It is of interest to note that of the genus Phaseolus the Adsuki bean is the only seed so far studied which is well utilized without cooking, although addition of cystine was necessary before its proteins were

available for normal growth. The nutritive value of the press cakes from peanuts, soy beans, tomato seeds, and coconuts as supplements to corn is being determined by a series of feeding experiments. Results indicate that when 25 per cent of certain of these concentrates is added to corn, the rate of growth is normal.

THE PHYTOCHEMICAL LABORATORY.

The phytochemical laboratory, established in 1916, has been ascertaining the nature of the chemical substances which impart to some of the edible fruits their peculiar aroma, of which until recent times practically nothing was known. In the absence of such information many of the forms of adulteration of natural fruit juices and artificial flavoring materials can not be controlled. The first investigation of this kind conducted here was with apples. On the basis of the results obtained a public service patent has been granted for the production of a "synthetic apple oil," which contains only such substances as have actually been found in the apple. This may find useful application for flavoring purposes. Other work along this line has been undertaken, notably in connection with the odorous constituents of peaches. A method for the detection of methyl anthranilate, a chemical substance suspected of being used as an artificial flavor in grape products, has been devised. An investigation is in progress to determine whether methyl anthranilate is a natural constituent of different kinds of grapes.

In collaboration with other branches of the Department of Agriculture, this laboratory conducts chemical investigations upon such plants or plant products as are deemed to be of medicinal or economic importance. For example, when during the World War a caffeine famine threatened, it made a survey of the North American Ilex species and determined that *Ilex vomitoria*, which occurs more or less abundantly along the coast from Virginia to Texas, contains in its leaves an appreciable amount of caffeine. Further attention was directed to another hitherto unknown source of caffeine, the pulp of the coffee berry, millions of pounds of which become available every year in Porto Rico and other coffee-producing countries.

THE LEATHER AND PAPER LABORATORY.

The leather and paper laboratory is concerned with those agricultural products which are utilized by the leather, paper, and naval stores industries, and also investigates the waterproofing, mildewproofing, and fireproofing of fabrics for farm and other uses and the utilization of wool-scouring wastes. Its only regulatory work is an occasional examination of turpentine sold for drug purposes.

NAVAL STORES.

The object of its naval stores (turpentine and rosin) studies is to improve methods of production, eliminate wastes, develop better methods of handling, storing, shipping, and testing, including accurate grading and weighing, to prepare specifications, to discover new uses or improve the adaptation of these materials to regular uses, and to furnish information on annual production and stocks in the hands of producers, dealers, and consumers.

As is generally known, rosin is sold by grade which is determined by the color and the presence of dirt. Up to March, 1914, there were no objective standards for grading rosin. The grading samples used were made of rosin and therefore were subject to rapid changes in color, especially when used in or exposed to sunlight. Inaccuracy in grading was exceedingly frequent and misgrading particularly prevalent when the Bureau of Chemistry began a systematic study of the subject, which resulted in the development of permanent glass types made to match the grades long recognized in the trade, put up in precisely the shape of the regular rosin-grading types the trade had been using and capable of being handled in the same way. These permanent glass types were approved and adopted by all boards of trade and chambers of commerce of the primary naval-stores markets of this country, and sets of them have been deposited at all of the naval-stores trading centers in the United States and at one point in England (London), where they are accessible to the industry. Furthermore, since 1915 all grading samples made of rosin have been made to match the permanent glass rosin types. Thus, very simply and without disturbance of trade practices, the bureau has substituted definite, permanent grading types for the indefinite changeable types formerly used. Related to the work which led to the introduction of objective rosin grades is the investigation now in progress to determine the constants and composition of rosins from different kinds of timber or of rosins of different grades.

There has been but little improvement in turpentine still practice and in packing, handling, and trading in turpentine and rosin since the early days of the industry, in the case of the smaller operators. During the seasons of 1915, 1916, and 1918, therefore, field parties from the bureau studied thoroughly the operations of more than 500 stills and made suggestions and recommendations for improvement in the equipment and processes. Decided betterment in the industry has resulted from this demonstration work, which later was supplemented by forceful posters and circulars, all aiming to drive home the lesson of better and more economical working, as well as the value of combining naval stores production with farming to the extent of raising foods for the animals and, as far as feasible, for the laborers employed. In this connection a study was also made of production costs and the information thus secured is serving as the foundation for a simple system of accounting to enable the smaller operator especially to know more definitely the exact condition of his business.

Better grades of rosin bring a much higher price than the lower grades. Heretofore this difference in value between grades below "G" and those above "WG" has been anywhere from $1 to $2 a 280-pound barrel. For various reasons many producers do not succeed in making the higher grades. In fact, the making of only high-grade rosin by the small producer is hardly practicable with present methods. It has long been the practice, especially in France, to convert the lower-grade rosin into a higher grade by exposing the product in very shallow pans to the sunlight, which bleaches out the color. As this procedure is not at all suited to the American industry, a more rapid and acceptable method was sought, resulting in the distillation of rosin under a high vacuum. This can be done without much decomposition, with the production of rosin better than XX from

"A" or "B" grades. The yield varies from 60 to 80 per cent of undecomposed rosin, and there is reason to believe that the higher figures can easily be obtained in practice. A public patent has been granted on this process, but it has not been developed industrially, primarily because during the war the difference in price between low and high grades was not sufficient to warrant it. The procedure, however, is available for development on the industrial scale whenever conditions warrant, and also is serving the bureau as a means of studying rosin and the decomposition products resulting from improperly controlled distillation by the ordinary procedure.

The use of rosin in making varnishes has been steadily increasing, until it is now known to the industry that varnishes made from the so-called rosin esters are more durable and less brittle than those made from unmodified rosin. Rosin esters are obtainable on the market, but are not always uniform, nor are the results obtained with them always entirely satisfactory. With the view to developing the best methods for the production of a uniform product, investigations on the preparation of rosin esters have been inaugurated during the year.

The methods of making wood turpentine have changed materially within the past 10 years. The demand for pine oil and other heavy oils for use in the flotation of minerals has led to the more careful refining of wood turpentine to extract from it all of the heavier oils which can be classified under the general term of "pine oil." Furthermore, the use of petroleum oil solvents has increased and there are now on the market a number of wood turpentines which are made by the solvent extraction process. In the preparation of interdepartmental specifications for the purchase by the Government of turpentine and in the preparation of specifications for the American Society for Testing Materials, specifications on which most of the turpentine bought by the larger consumers is purchased, information on the constants of present-day wood turpentine was found necessary. Samples of the regular stocks of the various makes of wood turpentine, both steam and destructively distilled, and also fractions of these turpentines taken during the refining distillation of the crude-wood turpentines, have been examined to establish their constants and their content of mineral oils. The results of this investigation are now being prepared for publication.

A practical method for refining wood turpentine, which involves the preliminary boiling, under a reflux condenser, with a sodium carbonate solution, followed by the distillation of the turpentine, has been thoroughly worked out. Boiling the crude turpentine with sodium carbonate solution resinifies certain objectionable light oils to which the strong odor of many wood turpentines is primarily due, and insures their elimination on subsequent distillation. A study on an industrial scale of the distillation of resinous wood under definitely controlled temperature conditions has been made.

Until within the last few years the detection and determination of small quantities of mineral oil in turpentine has been difficult and uncertain. In fact, no method could be relied on to detect less than 10 per cent of mineral oil, and adulterators had become so expert that even as little as from 2 to 5 per cent was frequently added at a profit. Undertaking to correct this condition, the bureau worked out a quick, easy, and certain method for detecting and determining

mineral oil in turpentine, which has been adopted as the standard throughout this country, and is included in the interdepartmental, American Society for Testing Materials, and Pharmacopœia specifications for turpentine. In addition, a reliable method for the detection and estimation of added coal-tar oils in turpentine has recently been developed. An accurate method for the determination of acetic acid in pyroligneous acid has been evolved, while a study resulting in the improvement of the method for the determination of methyl alcohol in pyroligneous liquors has been concluded.

For the past eight years the bureau has kept in close touch with the old practice, unfortunately not yet abandoned, of misgrading rosin and adulterating turpentine. In many instances more than 50 per cent of the rosin in a shipment had been misgraded and from 20 to 25 per cent of all the samples of turpentine which the bureau has examined were adulterated with mineral oil. Against these practices neither the producer nor the smaller ultimate consumer has the least redress, and after careful consideration the bureau has concluded that they can not be eliminated without Federal legislation.

In the matter of the grading and analysis of turpentine and rosin, pitches, and materials related thereto, the laboratory has continued to cooperate with the supervising inspectors of naval stores of Georgia, Florida, and the New York Produce Exchange, with the Turpentine and Rosin Producers' Association, with the National Oil, Paint, and Varnish Manufacturers' Association, and with the American Society for Testing Materials. In a few instances, when it could do so without becoming entangled in a controversy and when requested by both parties to the transaction, the bureau has acted as referee in disputes as to the purity of shipments of turpentine and the correctness of the grading of deliveries of rosin. It has followed this course only in such instances as promised to furnish information of value to the bureau in its naval stores research work.

Except for the decennial census figures and the statistics on the receipts and stocks at the primary naval stores ports, Savannah, Ga., and Jacksonville and Pensacola, Fla., no definite figures or information concerning the annual production and stocks of turpentine have been accessible. The result has been a widely fluctuating market, detrimental to producer and consumer alike. At the urgent request of the industry, therefore, the bureau began the collection of statistics of production and stocks in the hands of producers, dealers, and consumers in 1918, and has issued these semiannually since that time. It has been necessary also to compile a complete list of turpentine producers and one of the prime consumers of turpentine and rosin, both of which have been much sought by the industry. The list of producers served the Bureau of the Census as a guide in making its 1919 census of production. As soon as issued the reports are distributed to the public press and a copy is sent to each producer and consumer on the bureau's lists.

One of the big problems of the far Northwest is the clearing of land for agricultural purposes. As a large proportion of this land is cut-over western yellow pine, it seemed possible that the expense of clearing this land might be met, in part at least, by some method of utilizing the stumps of these trees. In an investigation, undertaken in cooperation with the forestry department of the University of

Idaho, two years were devoted to a study of the yields obtainable by destructive distillation from the western yellow-pine stumps of Idaho and Washington. The general conclusion was drawn that in certain localities many stumps in ordinary times can be profitably used in the production of wood turpentine, pine oil, tars, and charcoal, thus affording some return to the homesteader for this otherwise useless material that must be removed before he can get his land in final shape. Detailed results of the work will soon be published as Department Bulletin 1003.

During the year Department Bulletin 898, "Turpentine, its Sources, Properties, Uses, Transportation, and Marketing with Recommended Specifications," was published. The first edition was entirely exhausted within three months, making it necessary to prepare a revised edition to meet the demand.

TANNING AND LEATHER.

Research upon tanning and leather is one of the old, long-established lines of investigation in the Bureau of Chemistry. Work of this type has been done in the Department of Agriculture from the time of its establishment. The project assumed such importance that a special laboratory, the dendro-chemical laboratory, was established for it and related work in the organization of which the Forest Service and the Bureau of Chemistry cooperated. At the close of this cooperation the work was continued without interruption in the leather and paper laboratory, organized in July, 1904, by direction of Secretary Wilson. No technical investigations have a more intimate relation to agriculture than leather and tanning studies, since the material used in tanning originates on the farm and range and in the forest, the leather industry furnishes the farm business with one of its important markets, farmers as a class are the largest users of the finished articles made by the tanner and the manufacturer of leather goods, and finally, the materials and the process of the tannery are very largely biological.

Already the country is importing almost half the hides and a large percentage of the tanning material it uses. If it is to maintain permanently its preeminence in the leather industries, methods must be devised for the manufacture of better leathers at the lowest cost, for the better utilization of native tanning materials and hides and possibly for the creation of a synthetic tanning materials industry, probably not an inachievable goal for the modern science of organic chemistry. Although tanning is one of the oldest of the arts, most of it is still done by rule of thumb methods. Science, instead of pointing the way, is still far behind practical experience. If science is ever to lead the way in this industry, many separate sciences must be focused upon its problems—agriculture, zoology, botany, microbiology, analytical, organic, and colloid chemistry, and, to some extent, engineering. Of all the Government services the Department of Agriculture alone now employs a considerable body of experts in each of these branches.

The tanning and leather work of the Bureau of Chemistry includes investigations on the handling of hides, on the sources of tanning materials, on the processes of leather making, on the recovery and utilization of tannery and leather wastes, and on the

properties and uses of leather and leather substitutes, leather dressings, and finishing and treating materials.

There is a tremendous aggregate loss in hides and skins through ignorance of the proper methods of handling "country" hides and skins. As a matter of education, Farmers' Bulletin 1055, "Country Hides and Skins: Skinning, Curing, and Marketing," was issued, in cooperation with the Bureau of Animal Industry and the Bureau of Markets. Supplementing this bulletin, an interest-arousing poster, "More Money for Better Hides," was prepared. New editions of both became necessary within a few months. To promote the educational campaign thus started and to drive the lessons home, the office of exhibits displayed defective sides and sections of leather at the various State fairs and the International Live Stock Exposition in Chicago.

For the past several years there has been a growing interest in tanning on the farm or on a small scale, probably due to the fact that the farmer or small producer of hides and skins gets very little for them and must pay relatively high prices for the leather articles he buys. Despite much urging that the bureau issue instructions for tanning on a small scale, it has not felt justified in doing so, partly because of the lack of reliable information on small-scale tanning and partly because of the probability of frequent failures on the part of inexperienced persons who attempt small-scale tanning. Work looking to the ultimate development of suitable methods for small-scale operations has, however, been undertaken. Directions for making alum-tanned lace leathers already have been issued. In the meanwhile advisory leaflets of the nature indicated by the following titles have been distributed: "Note on Salting and Curing Hides on the Farm"; "Information on Having Hides Tanned," together with a list of tanners who have written the bureau that they tan leather and furs for farmers; and "Buying Leather by the Side."

As domestic supplies are growing inadequate, numerous investigations of various materials as possible sources of tannin have been made. Among these may be noted foreign woods and barks, samples of which have been analyzed for the office of foreign plant introduction, willow bark, waste hemlock, domestic nut galls, saw palmetto roots, and paper-mill waste spruce and fir barks. Willow barks contain enough tannin to be valuable if sufficient quantities can be brought together at a low cost. Paper-mill waste spruce bark contains enough tannin to warrant further study, provided it is feasible to separate it in the mill from the fir bark which contains but little tannin and imparts an objectionable color to leather. Perhaps the most abundant incompletely utilized domestic source of tannin is sumac. The Bureau of Chemistry has attempted to stimulate the gathering and use of this abundant wild plant, issuing in this connection Department Bulletin 706, "Sumac: A Valuable Tanning Material and Dyestuff," a new revised edition of which became necessary this year. Examinations of commercial leathers indicate that a good deal of the leather on the market contains excessive quantities of uncombined tannin, representing a waste of but little less than $1,000,000 worth of tannin yearly.

In many instances tanners and others have received help, three examples of which may be cited. A number of tanners were shown

that in their plants the tan bark was being extracted so poorly that more than half the tannin normally present remained in it. In cooperation with the Bureau of Animal Industry, assistance was tendered to some northern tanners in determining the character of a peculiar defect of certain skins, which was not apparent until the skins were split. The trouble was found to be due to follicular mange, and suggestions were given to aid in recognizing such defective skins before splitting, thereby conserving many skins suitable for certain kinds of leather but almost an entire loss if used for split leather. Difficulties in unhairing some hides were shown to be due to curing with salt containing alum, which set the hair by a partial tannage. A news note of warning against the use of such salt was given wide publicity.

With a view to helping to mitigate public nuisances and to recover all possible by-products, many samples of tannery liquors, wastes, and recovered products have been analyzed to learn their value, usually for fertilizer purposes. Procedures advocated by the bureau have been worked out successfully on a commercial scale. Two articles, "The Purification of Tannery Effluents" and "The Purification of Tannery Effluents and the Recovery of By-products Therefrom," summarize the best available information.

Much work was done, especially during the war, in determining the efficacy of waterproofing compounds for leather. The laboratory aided the War Department in the selection of the best from among the materials submitted and in the preparation of specifications for their purchase. Furthermore, several original formulæ were devised for the waterproofing of sole and upper leathers.

Scientific investigations of chemical processes of manufacturing are possible only if exact quantitative analytical methods are available, by means of which the various stages of the process can be followed and the character of the final products determined. The chemical nature of the materials and processes of the tannery are so little known that correct methods of analysis are comparatively few. The leather and paper laboratory has devoted much attention to the development of such methods. The official method of the American Leather Chemists' Association for glucose in leather is this laboratory's work. A fluorescence test for oak bark has been elaborated to determine the use of this bark in the preparation of tanning extracts and leather. Other papers dealing with analytical methods have been published under the following titles: "Free Sulphuric Acid in Leather," "The Preparation of Heavy Leather Samples for Analysis," "The Solvent Action of Petroleum Ether and Chloroform on Leather Stuffing, Oils, and Greases," "Kaolin for Tannin Analysis," "Epsom Salts in Leather," "The Determination of Moisture in Leather," "The Extraction of Oils, Greases, and Soaps in Leather," and "Comparison of the Gravimetric and Volumetric Determination of Epsom Salts in Leather."

Work on the determination of glucose and Epsom salts was done in connection with the study of the practice of "weighting" or "loading" heavy leathers sold by weight, particularly sole leather. To ascertain the extent of this practice, some years ago a representative number of commercial sole leathers were examined. Of these 63 per cent were weighted with Epsom salts or glucose, or with both. These findings, published in Bureau of Chemistry Bulletin 165, "Leather

Investigations," evoked criticism which is believed to have had a salutary effect.

The identification of the kind of skin from which a given finished leather was made is often important in detecting imitations. The hair hole formation and distribution are characteristic for different kinds of skins. A procedure for photographing wax impressions of this formation so as to bring out detail and contrast has been evolved.

As necessary as reliable analytical methods in studying scientifically the materials and processes of leather production are accurate service tests for the finished leather. No other method can furnish equally reliable information concerning the suitability of a leather for the use for which it is destined. In fact, progress in developing processes for increasing the wearing quality of leathers, especially sole leathers, will be seriously hampered until some means of quickly and accurately proving or determining the relative value of proposed improvements has been obtained. The Bureau of Chemistry was probably the first to scientifically approach this problem which has since aroused the interest of others. A series of machines for determining quantitatively the wearing quality of sole leather have been constructed, and the data thus obtained have been made public. In spite of some notable progress, however, the development of mechanical serviceability tests is still in its infancy. In solving this problem it is necessary to check the mechanical wearing experiments against extensive actual wearing experiments. Such tests have been made by the bureau with boy scouts, with civilians, and with infantry.

Of as great importance as the more economical production of better leather is its more rational use. The bureau has endeavored to bring this about in two ways, by educating users and by studying the factors that cause leather to deteriorate. Information on this subject has received the widest publicity, largely through Farmers' Bulletin 1183, "The Care of Leather," which is being used after the manner of a textbook by several institutions.

It is essential that certain leathers have a long life, as, for example, those for bookbinding and upholstering. This laboratory and others proved sulphuric acid, which formerly was quite freely used at certain stages of the manufacturing process, to be very injurious. Progressive tanners, having been brought to a realization of this fact, are making appropriate modifications of their processes. Of even greater importance for belting, strap, and harness leathers is the effect the various oils and stuffing materials may have upon the leather. In studying this problem, however, the laboratory found that the fundamental conditions for obtaining quantitative strength tests must first be worked out, since preliminary results indicate that relative humidity and possibly temperature materially affect the strength of leather.

Throughout its history the laboratory has done work for and cooperated with other Government agencies and with such associations as the American Leather Chemists' Association and the Association of Official Agricultural Chemists. At one time it conducted a good deal of routine testing of Government purchases, but this has been turned over to other agencies in order to permit it to devote all its resources to constructive work. During the war assistance was given the War Department, especially on bag, strap, harness, upper and

sole leather, in determining the suitability of certain leathers for special purposes, in the physical testing of leathers, and in ascertaining the efficacy of finishing materials and treatments. Advice was given the War Department, the Council of National Defense, and the War Industries Board in drawing up and revising specifications for leather. Members of the laboratory have often acted in an advisory capacity for other agencies of the Government, such as the Panama Canal Commission, the Tariff Commission, the Treasury Department, the General Supply Committee, and the Federal Trade Commission. In connection with studies by the Bureau of Plant Industry on the chestnut blight, samples of chestnut bark from blight-resistant and nonresistant trees were analyzed for tannin and other constituents. At the request of the Interior Department, methods used for tanning alligator skins have been surveyed and a full report made to the Indian Commission which contemplated the establishment of this industry among the Indians of Florida.

WATERPROOFING, MILDEWPROOFING, AND FIREPROOFING FABRICS.

For years the Department of Agriculture has been asked by farmers for information on the waterproofing, mildewproofing, and fireproofing of cotton duck to be used out of doors for wagon, stock, shock and hay covers, for tents, paulins, awnings, etc. Work to secure the information demanded was begun in 1916. Called upon to assist the War Department in testing the character and the effectiveness of various waterproofing treatments for canvas, the bureau was charged with all the work of this nature during the continuance of the war.

Several mold species considered representative of those causing the mildew of canvas have been identified and used in the laboratory work in the determination of the mildew resistance of various mildewproofing processes.

The following publications on the waterproofing and mildewproofing work have been issued: Farmers' Bulletin 1157, "Waterproofing and Mildewproofing of Cotton Duck;" "The Determination of Water Resistance of Fabrics;" "Testing the Mildew Resistance of Textiles;" and "The Water Resistance of Treated Canvas During Continuous Exposure to Weather."

Some time has been devoted to a study of methods for fireproofing canvas fabrics for outdoor use, especially in cooperation with the War Department, in a search for a water-resistant fireproofing treatment, particularly for camouflage purposes. Many experiments were made with numerous treatments, including those usually recommended, but up to the present time no fireproofing treatment has been found which is weatherproof.

WOOL-SCOURING WASTE.

Approximately 600,000,000 pounds of raw unscoured wool are used in this country annually. Unscoured wool shows approximately a loss of 40 per cent in scouring, this loss consisting of dirt, suint, and grease. The grease content averages around 15 per cent, while the potash (K_2O) averages about 4 per cent. On the basis of these figures, unscoured wool contains about 90,000,000 pounds of wool grease, and 24,000,000 pounds of actual potash, annually. If converted into lanolin and refined wool grease, large quantities of which

are used in this country as a basis of ointments and cosmetics and for medicinal purposes, the wool grease would more than supply all domestic needs. A small quantity of the wool grease, which has long gone to waste in this country, is now being recovered, but all the potash, which is greatly needed for agricultural purposes, is still contributing to the pollution of streams. In 1918 the importance of the matter was laid before Congress, which has appropriated annually $9,000 for the study of this problem.

In addition to the grease and potash, a small percentage, usually less than 1 per cent, of nitrogenous material is removed from wool by scouring. Concentrated wool-scouring waste, from which the greater part of the grease had been removed, was mixed with various regular fertilizer materials, such as acid phosphate, steamed bone meal, and leather scrap, and in every instance found to yield a mixed fertilizer of excellent texture, with the potash water soluble and the availability of the other constituents unreduced. Experiments on the industrial scale indicate that it may be profitable to take these offensive wastes out of the country's watercourses by using them in the manufacture of fertilizers, thus returning to the farm a part of the fertilizer constituents removed in the raw wool.

The bureau is cooperating with wool scourers in improving the methods of recovering and utilizing the grease and potash and especially in improving the methods of refining the crude grease. Methods devised in the laboratory are now being developed on an industrial scale in a wool-scouring plant. Ordinary wool grease is used chiefly in the leather industry, in cordage and printing inks, and for the manufacture of lanolin. The laboratory has found that when properly refined it is particularly valuable for currying leathers and waterproofing canvas.

PAPER.

In 1913, the investigations on paper and paper-making materials had long been in progress; in fact, this was among the oldest and best established lines of technical work of the bureau, which was regularly called upon by the several departments, especially by the Government Printing Office, to pass upon deliveries of paper. After this work had long been in progress the Bureau of Standards began the testing of papers, with the result that two Government agencies were engaged in the testing of deliveries of paper for the Government departments. Though the two bureaus were serving in the main different governmental agencies and therefore not testing the same deliveries, it seemed uneconomical to the Bureau of Chemistry to have the work thus divided. Therefore, though not responsible for the situation, the Bureau of Chemistry in July, 1914, brought about the transfer of this and certain other testing of deliveries for the Government departments, together with the appropriate funds, to the Bureau of Standards. Since that time, so far as possible, it has devoted its efforts, in cooperation with the Forest Service, to the study of the serviceability and durability of paper, paper-making materials, and related matters.

Specifications which are the basis for all purchases of paper made by the Federal departments, and which have been followed extensively by other large users of paper, have been prepared. For 10 years or more the bureau has served the Joint Committee on Print-

ing of Congress, the General Supply Committee, the Navy Department, the War Department, Post Office Department, and other Government departments in the preparation of specifications for paper for various purposes. This work has produced many results, not always tangible, including a more intelligent and fair competition in bidding on Government supplies, more uniform delivery of specified papers, the use of paper better suited for the purpose in hand and the more economical and conservative purchase of paper. Savings of many thousands of dollars annually in the purchases of the Government Printing Office, the Post Office, and other departments have resulted from the use of more suitable and lighter papers based on the tests and recommendations made by the Bureau of Chemistry.

Investigations on blue and brown print paper, including the devising of an economical method of preparing potassium ferricyanide, have resulted in the establishment of the manufacture of such papers in this country. Government engineers and others can now procure here all the blue print paper needed and of a quality superior to that formerly obtained from abroad. Methods devised for testing plue print paper have made it possible for any purchaser to specify rigidly and to secure the quality of paper suited to his needs. As a result of the investigations on blotting paper, the Government has adopted much lighter weight paper for blotting purposes, thus effecting a saving of from 40 to 60 per cent in cost. A method which is simpler, more easily executed, and more uniform than those heretofore commonly employed has been developed for the testing of blotting paper.

At the request of the Bureau of Engraving and Printing, cooperative work has been conducted on the effect of relative humidity on currency paper and the processes of engraving, sizing, and finishing.

At the request of the Navy Department, specifications based on actual service tests were prepared during the war for a special reinforced type of fiber container to be substituted for the wooden box in the overseas shipments of canned goods. This necessitated the designing and construction of a new testing machine known as the impact tester.

Work was done for the War and Navy Departments in the development of a strong water-resistant paper for wrapping bales for overseas shipment. Specifications for such paper were prepared and methods of testing it were developed.

Assistance was given the War Department in determining the moisture resistance of fiber containers offered for powder charges to be used in the larger guns.

The investigations on the water resistance of fiber boards and adhesives used in the manufacture of solid and corrugated fiber and wall boards have greatly stimulated the interest of the industry, especially in the effects of these adhesives upon the board and its water resistance, and in the value of proper rosin sizing of the board to increase its water resistance. Following the work which the bureau did on these subjects, fellowships were established by the industry at educational institutions to investigate further these technical problems, while greater economy in the use of adhesive and increase in the durability and water resistance of the board have followed. The deteriorating effect of certain adhesives has been shown, and methods

for reducing such effects have been devised. New adhesives discovered by the Bureau of Chemistry are being studied.

From the beginning of its active paper work the Bureau of Chemistry has contributed much to the origination and improvement of methods and apparatus for testing. It originated the standard methods for determining the fiber composition of papers, a method now almost exclusively used by commercial and mill testing laboratories. It developed a standard method for the determination of rosin size, for the determination of the absorption of blotting paper, for testing blue and brown print papers to ascertain their durability and serviceability, for the determination of the translucency of paper, the degree of sizing, and resistance to moisture. It has greatly improved one of the generally used strength testing machines, making it more accurate and rapid. It has developed a machine for testing fiber board and the methods for expressing the strength factor of paper. It installed and has operated for 12 years the only constant humidity and temperature room which is known to be in actual operation.

Twenty-four publications have so far been issued, and the work for four others has been completed.

THE INSECTICIDE AND FUNGICIDE LABORATORY.

The work of the insecticide and fungicide laboratory consists in: (1) The examination of insecticides and fungicides, including disinfectants, for the Insecticide and Fungicide Board; (2) the examination of insecticides and fungicides for the bureaus of the Department of Agriculture, particularly the Bureau of Entomology and the Bureau of Plant Industry, and for other departments of the Government; (3) investigation and research in connection with the production, properties, and application of insecticides, fungicides, and related products, in cooperation with the Bureau of Entomology and Bureau of Plant Industry, studies on the effect of insecticides and fungicides on plants and the contamination of the sprayed products from the standpoint of the consumer, and the development of new insecticides and fungicides and the study of their properties; (4) research upon appropriate standards for insecticides and fungicides, upon adulterants and the means of detecting them, and upon the methods of analyzing insecticides and fungicides.

EXAMINATION OF INSECTICIDES AND FUNGICIDES.

Under the first two items the laboratory has analyzed since 1913 more than 10,000 official samples of insecticides and fungicides, including disinfectants, for the Insecticide and Fungicide Board, and more than 4,000 samples of insecticides and fungicides and related products for other bureaus of the department. Several thousand other analyses have also been made in connection with the research work of the laboratory.

INVESTIGATIONS ON INSECTICIDES AND FUNGICIDES.

The principal activities embraced under the third heading are: An investigation of the toxic effect on fruit trees of certain constituents used in insecticides, particularly copper and arsenic, to determine whether or not the continued use of insecticides or fungi-

cides might ultimately result in a serious accumulation of these toxic substances in the soil and cause injury to trees or plants through absorption of poison by the roots. Several new lead arsenates and lead chlor arsenates were prepared and their properties determined. The cause of injury to foliage by di-lead arsenate was found to be due, in many cases, to its decomposition by salts that occur naturally in the waters which are used in its application. It was also shown that di-lead arsenate is decomposed by pure water alone, although this action is extremely slow. The final products of decomposition are arsenic acid and a basic lead arsenate. This work is of value in showing how injury may occur when treated foliage is subjected to the frequent action of light rains, fog, or dew. Field and laboratory experiments to determine the effect on foliage of Paris green containing varying amounts of soluble arsenic and the development of a laboratory method by which this can be determined have been conducted.

In cooperation with the Federal Horticultural Board, a method of fumigating cotton bales with hydrocyanic acid gas, to guard against the introduction into this country of the pink boll worm, was devised. Cooperative experiments have also been carried on to devise methods of fumigating foodstuffs, such as seeds, milled grains, vegetables, fruits, etc., in order to destroy insect life without rendering the food unfit for human consumption. A study of larvæcides for preventing the development of the house-fly larvæ in horse manure resulted in the discovery of useful methods for the control of this pest. In cooperation with the Bureau of Entomology, an investigation to determine whether or not honey bees are killed by feeding on blossoms of trees that have been sprayed with arsenicals was made.

More than 3 tons of a new tree-banding material here developed were made in the laboratory for the experimental use of the Bureau of Entomology in its work to control the gypsy moth in Massachusetts. This material proved so satisfactory for this purpose that many tons are now used annually in commercial control work. It is superior to and can be prepared at a much lower cost than anything previously on the market for the same purpose.

An investigation of the calcium arsenates has been made and several new calcium arsenates have been prepared and their properties studied, some of the results of which appear in Department Bulletin 750, "A Method of Preparing a Commercial Grade of Calcium Arsenate." A method for the commercial preparation of calcium arsenate has been developed and a patent covering the process has been dedicated to public use.

In an investigation on the toxic action of certain gases on insects, seeds, and fungi, made in cooperation with the Bureau of Entomology, the action of phosgene, arsine, cyanogen chloride, chloropicrin, illuminating gas, and carbon monoxide were studied. Cyanogen chloride and chloropicrin gave promise of being useful for fumigating purposes. Neither, however, can be used in greenhouse fumigation on account of their injurious action on plants. The results of this work were published as Department Bulletin 893, "Experiments on the Toxic Action of Certain Gases on Insects, Seeds, and Fungi."

An investigation upon Pickering sprays and other copper Bordeaux mixtures, carried on in conjunction with field experiments for four

seasons, gave much valuable information which is published in Department Bulletin 866, "Pickering Sprays."

A study of the toxicity of various arsenical preparations on insects has been under way for two years. This work will be of much practical benefit in connection with the use of insecticides.

Department Bulletin 989, "Pine-Oil and Pine-Distillate Product Emulsions," contains many chemical and bacteriological data and shows that pine-oil emulsion disinfectants are of very limited practical value, in that they are ineffective against some of the common pathogenic organisms. These emulsions, however, deteriorate but little with age, which is contrary to several statements published.

The laboratory is cooperating with the Bureau of Entomology in connection with its work at Riverton, N. J., to discover a method of controlling the Japanese beetle, which has become established there. Work in connection with the control of flies on live stock is being carried on in cooperation with the Bureau of Entomology branch laboratories at Dallas and Uvalde, Tex.

During 1917 and 1918, chemical investigations of the foliage of trees sprayed with lime-sulphur and copper sprays, with and without stickers, were made for the Bureau of Plant Industry to determine the effectiveness of stickers, as well as the sticking qualities of various copper and sulphur sprays. Investigations on the formaldehyde content of solutions used in treating certain grain smuts were made for the Bureau of Plant Industry. Investigations on the chemical and physical composition of mineral oils used in citrus spraying work were made for the Bureau of Entomology. Suggestions as to promising substances to use against bark and wood boring insects were made to the Bureau of Entomology and certain new mixtures prepared for test. Aid was also given to the Bureau of Entomology in the matter of certain insecticides used to combat the boll weevil.

The laboratory has examined many materials that gave promise of being valuable as insecticides or fungicides. The majority of these were vegetable products. Recently it has undertaken a study of the synthetic organic compounds with a view to discovering new valuable active substances. Among other compounds many pyridine and piperidine derivatives have been studied.

STANDARDS.

Researches carried on under the fourth heading are: An investigation to determine the amount of pyrethrum stems and sand in insect powders and establish allowable limits for these two ingredients, and one on the active principle of insect powder and methods for its determination; a study of the adulteration of insect powder with powdered daisy flowers and methods for determining this form of adulteration; an investigation on the occurrence of manganese in insect powder, the presence of which, it had been claimed by certain authors, was an indication of adulteration, demonstrating that manganese occurs in both stems and flowers and in greatly varying amounts, depending apparently upon the nature of the soil in which the plant is grown; an investigation of the method of production and composition of tobacco dusts sold on the market, undertaken primarily for the purpose of establishing standards for this product;

work on methods for the determination of alkaloids in hellebore, and an investigation on the amount of acid-insoluble ash in this material, for the purpose of establishing standards for powdered white hellebore, which have given much valuable information.

It has been claimed that commercial dry powdered calcium arsenate, containing lime in excess, undergoes decomposition on standing in the package, resulting in the production of water-soluble compounds of arsenic. This question is being investigated. Large samples of a number of commercial brands of calcium arsenate have been stored in different localities in various types of packages, and samples from them examined at definite intervals. The result of this work, which is nearly completed, indicate that very little, if any, deterioration occurs. At least it is not sufficient, during any reasonable time of storage, to be of practical importance.

METHODS OF ANALYSIS.

Many chemical methods for the analysis of insecticides have been developed, and a large amount of cooperative work for the Association of Official Agricultural Chemists has been conducted.

Much work has been done by the microscopist in connection with microscopic methods for the examination of insecticides, some of which are mentioned elsewhere in this report. Histological work on sandalwood and Derris is in progress.

PUBLICATIONS.

Thirty-five scientific communications have been made by the laboratory since 1913, and nine others are now ready for publication, the titles of those prepared during this year being as follows: "Arsenic, Copper, and Lead Remaining on Sprayed Fruits and Vegetables," "Arsenates of Calcium II," "Arsenates of Calcium III," "The Deterioration of Calcium Arsenate in Storage," "The Absorption of Copper from Soil by Potato Plants," "Chemical, Physical, and Insecticidal Studies of Arsenicals," "Domestic and Imported Veratrum (Hellebore)," "The Application of Optical Methods to the Examination of Insecticides and Fungicides," "Pine-Oil and Pine-Distillation Product Emulsions: Method of Production, Chemical Properties and Disinfectant Action," "Errors Caused by Nitrites and Nitrates in the Distillation Method for the Determination of Arsenic, and a Method for Their Elimination."

THE COLOR INVESTIGATION LABORATORY.

In the work of the color investigation laboratory the emphasis has been placed upon the study of the laws that govern the chemical reactions employed in the dye industry and the determination of the chemical and physical properties of the substances of importance in dye manufacturing. For such studies the factory chemist rarely has leisure or opportunity. Yet such knowledge is the foundation of the industry.

Since its establishment on December 1, 1915, the results of such of its investigations as have been completed have been announced in 50 scientific papers. Twenty public-service patents have been granted to members of its staff. The laboratory during the whole of its

brief existence has been handicapped by a turnover of its scientific personnel of about 200 per cent. The first and second director of the laboratory resigned to accept a more lucrative industrial post. Not the least of the services of the laboratory has been the training of chemists for the dye industry.

Soon after the United States entered the war the color laboratory was practically amalgamated with the Bureau of Aircraft Production. Studies were made of dope for airplanes, specifications for photographic materials were prepared, the testing of deliveries supervised, a method of preparing acetone from the gases of the Burton still was evolved, and studies were made upon smoke screens, camouflage schemes, and methods of signaling. In connection with this military work, photosensitizing dyes the equal of several of the former German dyes were produced and the methods of manufacture made public. Moreover, a new series of these dyes, named the "kryptocyanines," was discovered. They are characterized by having an extremely sharp sensitizing power farther out in the infra-red portion of the spectrum than any dyes previously known. This new series is most valuable in studying the solar spectrum, and has been supplied for this purpose to the Wilson Solar Observatory. Photosensitizing dyes, so far as they are not available through domestic commercial channels, are furnished to the people of the country, especially to physical-research laboratories and to photographic-material manufacturers. It is planned to close this project as soon as present methods of producing the dyes have been improved by the elimination of a large number of bothersome ether extractions which are very difficult to handle on a large scale. For some of the intermediate bases this result has been accomplished very satisfactorily.

Several analytical schemes which promise to be of great value to manufacturers have been evolved. Among them are the method for the rapid analysis of mixtures of chlorinated toluene, the use of benzaldehyde sulphite compound as a standard in the quantitative separation and estimation of benzaldehyde and benzoic acid, and methods of detecting different sulphonic acids of naphthalene possibly formed in sulphonations. The use of optical crystallographic methods has been introduced in the industry. The physical properties, such as melting points, boiling points, vapor pressure, and solubility curves, as well as various optical properties, of a number of important old and new compounds have been investigated.

Processes for sulphonating aromatic hydrocarbons in the vapor phase have also been devised and arrangements made for industrial development. Studies for the utilization of p-cymene, a waste product of the sulphite-paper industry, have been undertaken, and several dyes have been made from it. Methods of producing carvacrol and a synthesis of thymol have been evolved. Finally, a process for the catalytic oxidation of naphthalene to phthalic anhydride has been discovered. During the war this substance sold for as much as $7 a pound. After the discovery of this process cooperative arrangements were made with several manufacturing concerns of the country for testing it and producing phthalic anhydride on a large scale. They had had great difficulty in producing phthalic anhydride by the methods used in Germany before that time. The new process turned

out to be well adapted for manufacturing purposes, and the cooperating firms have even exported phthalic anhydride. The price at one time was as low as 45 cents a pound on contract.

During the fiscal year 1920–21 the members of the staff of the color laboratory contributed the following scientific publications: "Cellulose Phthalate, Its Preparation and Properties;" "The Absorption Spectra of the Nitric Esters of Glycerol;" "A Synthesis of Thymol from p-Cymene;" "Synthesis of s-Xylidine;" "Alkali Fusions: II. The Fusion of Sodium Benzene Disulphonate with Sodium Hydroxide for the Production of Resorcinol;" "The Use of Catalysts in the Sulphonation of Aromatic Compounds;" "Phthalic Anhydride: IV. The Vapor Pressure of Phthalic Anhydride;" "Naphthalene Sulphonic Acids: I. Some Difficultly Soluble Salts of Certain Naphthalene Sulphonic Acids;" "Naphthalene Sulphonic Acids: II. A Method for the Qualitative Detection of Some of the Naphthalene Sulphonic Acids;" "Naphthalene Sulphonic Acids: III. An Alternative Method for the Qualitative Detection of Naphthalene 2–7 and 1–6 Disulphonic Acids;" "Synthesis of Photosensitizing Dyes: II. Dicyanin;" "Isocyanin Dyes from Lepidine and Its Homologs;" "The Preparation of Lepidine and Related Bases;" "Tetra-methyl Quinolines;" "Kryptocyanines, a New Series of Photosensitizing Dyes;" "The Preparation and Technical Uses of Furfural;" "Phthalic Anhydride Derivatives: A Partial Collection of Names and References;" "Some Synthetic Resins from Furfural;" "A Compilation of American Dye Patents in Abstract Form." Four public service patent applications dealing with the preparation of furfural, of chloroform, and of photosensitizing dyes have been granted.

OFFICE OF DEVELOPMENT WORK.

The purpose of the establishment of the office of development work in 1920 is given on page 2 of this report, and its various activities in the development of the discoveries of the bureau's staff are mentioned wherever such discoveries are described. In addition to such activities, this office exercises general supervision over the bureau's work upon dust explosions and fires in mills, elevators, and thrashing machines, upon the production of gas from straw and other fibrous materials, and upon commercial dehydration.

GRAIN-DUST EXPLOSIONS AND FIRES.

The dust-explosion and fire-prevention project was inaugurated following a disastrous feed-dust explosion in Buffalo in 1913 by the millers of western New York. Since grain-dust explosions are very similar in character and genesis to coal-dust explosions in mines, in 1914 the Bureau of Mines invited the cooperation of the Bureau of Chemistry, which has continued ever since, though, as the work assumed greater importance to such agricultural industries as grain handling, flour and feed milling, and sugar refining, leadership passed gradually and naturally to the Bureau of Chemistry.

Soon after the establishment of this cooperation reports of frequent explosions and fires in thrashing machines in the Pacific Northwest, alleged to be of criminal origin, were received. The losses that year are said to have affected more than 300 machines and to

have amounted to at least $1,000,000. The bureau's engineers recognized these phenomena as dust explosions in the production of which three factors played an important part: Smuttiness of the wheat, causing great dust clouds of spores; dryness of the atmosphere; and static electricity produced by friction in the machines. Methods for grounding the machines were devised and automatic fire extinguishers and fans to remove the dust were installed. These eliminated for all practical purposes the explosion hazard, besides creating better working conditions about the machines and cleaning the grain so as to reduce dockage and transportation charges and increase the price received for the grain. The value of the bureau's recommendations has been recognized by underwriters, in that stationary thrashers in the State of Washington driven by internal-combustion motors and properly equipped with a dust-collecting fan in accordance with Department Circular 98, pay an insurance rate of $8.50 per $100, whereas machines not so equipped pay at the rate of $10.50 to $11 per $100.

The pathologists of the Bureau of Plant Industry believe that the use of fans on thrashing machines to remove spores and prevent their dissemination over the countryside promises to be an important factor in the control of the smut diseases of wheat. The Bureau of Chemistry is cooperating on this problem and during the 1921 season the project was extended to flag smut in Madison County, Ill. The Bureau of Markets believes that the fans if generally used will remove dirt and trash from wheat on the farms, which would be more in the public interest than to have it shipped as at present to market, there to be dealt with as dockage. In this project, too, the Bureau of Chemistry is cooperating.

The bureau's dust-explosion work has been an important conservation factor in the grain-handling and flour and feed milling industry. The explosibility of the dusts produced in these and other dusty industries has been demonstrated so conclusively that these industries are now taking precautions that formerly were never thought necessary. Many of the immediate sources of danger in these plants, such as static electricity, unprotected electric lamps, faulty design of buildings and machinery, uncleanliness, "choke-ups" in elevator legs, etc., have been discovered and pointed out to engineers, managers of plants, and underwriters. There has been active cooperation with fire marshals and underwriters. Undoubtedly much property loss has been prevented by the broadcast spreading of this information.

What can be accomplished was amply demonstrated during the war, when the Secretary of Agriculture made available out of the emergency appropriation $50,000 a year for a campaign to conserve grain and flour by preventing explosions and fires in mills and elevators. At meetings held in various parts of the country mill and elevator owners and employees were shown, by means of moving pictures, lantern slides, and miniature dust explosions, the danger of dust explosions and fires, and were made acquainted with the circumstances under which they occur. Following the meetings the various mills and elevators were inspected and recommendations made to the managers and superintendents with reference to arrangements that appeared dangerous. The men were then asked by means of special cards to pledge themselves to take all possible precautions to prevent

fires and explosions in the plants where they were employed. The signing of the cards was acknowledged by the department. Through posters, circulars, and the like, much publicity was given to the work. During the time this campaign lasted the losses from explosions and fires were about 40 per cent of those occurring in previous years. As no funds were available to proceed with the work after July 1, 1919, and as the United States Grain Corporation desired that it be continued as a form of insurance for its own operations, the force engaged upon this campaign was transferred to the rolls of the Grain Corporation. The work was continued by that corporation, the Bureau of Chemistry collaborating by furnishing general supervision. With the passing of the Grain Corporation on July 1, 1920, the total losses of the corporation from explosions and fires had been trifling. The results of the campaign were published by the Grain Corporation in the form of the proceedings of the New York conference of the men engaged in the work.

For lack of a specific appropriation, the work of the bureau during 1920–21 was limited largely to the preparation of the material accumulated in previous years for publication. Seventeen papers were published in various journals, as well as Department Circular 171, "Unprotected Electric Lamps—A Dust Explosion and Fire Hazard." Flour, starch, grain dust, spice dust, cottonseed meal, aluminum dust, fish meal, hard-rubber dust were among the materials reported as being capable of causing explosions.

In the course of this work it was discovered that a part, perhaps the greater part, of the fires common in cotton gins, especially in nonhumid regions like Texas, are due to static electricity. A scheme for wiring and grounding gins was devised and applied to a few of them. While the number of such gins is too small to justify sweeping conclusions, it is highly probable that such wiring furnishes valuable protection. Funds have never been available to prosecute this work as vigorously and extensively as the extremely serious losses involved would demand.

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